TAC Project

1/20/82

Block Diagram (Rough Proposal)

Consult with Mike A. on
the interface.

Start a product survey
Carrie call for terminal information.
Poll people here.

~~Organize a file for project~~

TAC

12/9/81

602-935-6522

3 F 111 Jon Need Answer March H/W

6 F 15

? F 16

? AWACS

Action Item

Specification of Display System in Jan. 82

~~Price Range~~

Schedule also

March Software to start on F-111 prototype

→ prototype needed in March

TAC

F 111

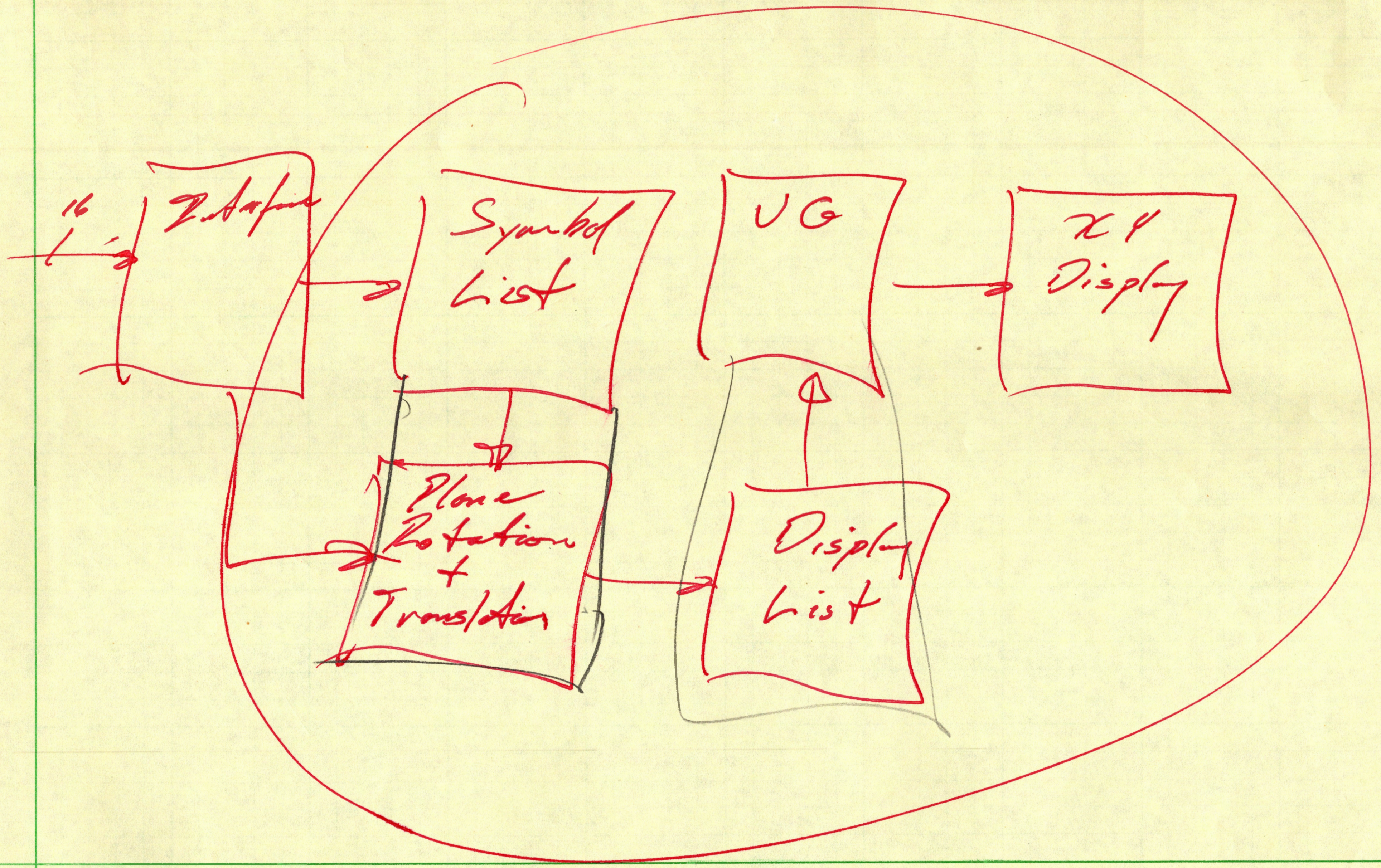
12/9/81

Circle used only for Test Display

No rotation or scaling

ECM trainer

22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
AMPAD


16
Interface
Symbol List
UG
XY Display
Plane Rotation + Translation
Display List

Inter Office Memo

ATARI®

Coin Operated Games Division

To: File

From: Roy Machamer RM

Subject: Vector Display, Project #358 Date: 12/15/'81

Consesus of Dave Stubben, Rick Moncrief, Steve Calfee on the proposed R&D project was: Target Goals

1. The Display - any color or BW tube but first article would use available 19 inch BW, Rick would reconfigure to long persistance green for TAC if needed in March.

2. Vector Generator - the analog system as used in Warp Speed.

3. Math Box - as used in Warp Speed.

4. I/O - standards IEEE488, and a parallel of unspecified type. Baud rates 110-9600, and a 20ma current loop.

5. Mechanical - 3 each 11½ x 12 inch boards.
   RF cage for 4 boards
   Fan cooled
   Normal TV aspect
   Target

ACTION

A. Immediate - collect manuals on the Tektronics, DEC and other graphic terminals to determine function and features of Atari units.

B. Warp Speed - Stubben, Moncrief to Red line schematics for mod to this use.

C. Software - Calfee to outline software needs.

D. Market research - collect available studies on this market segment.

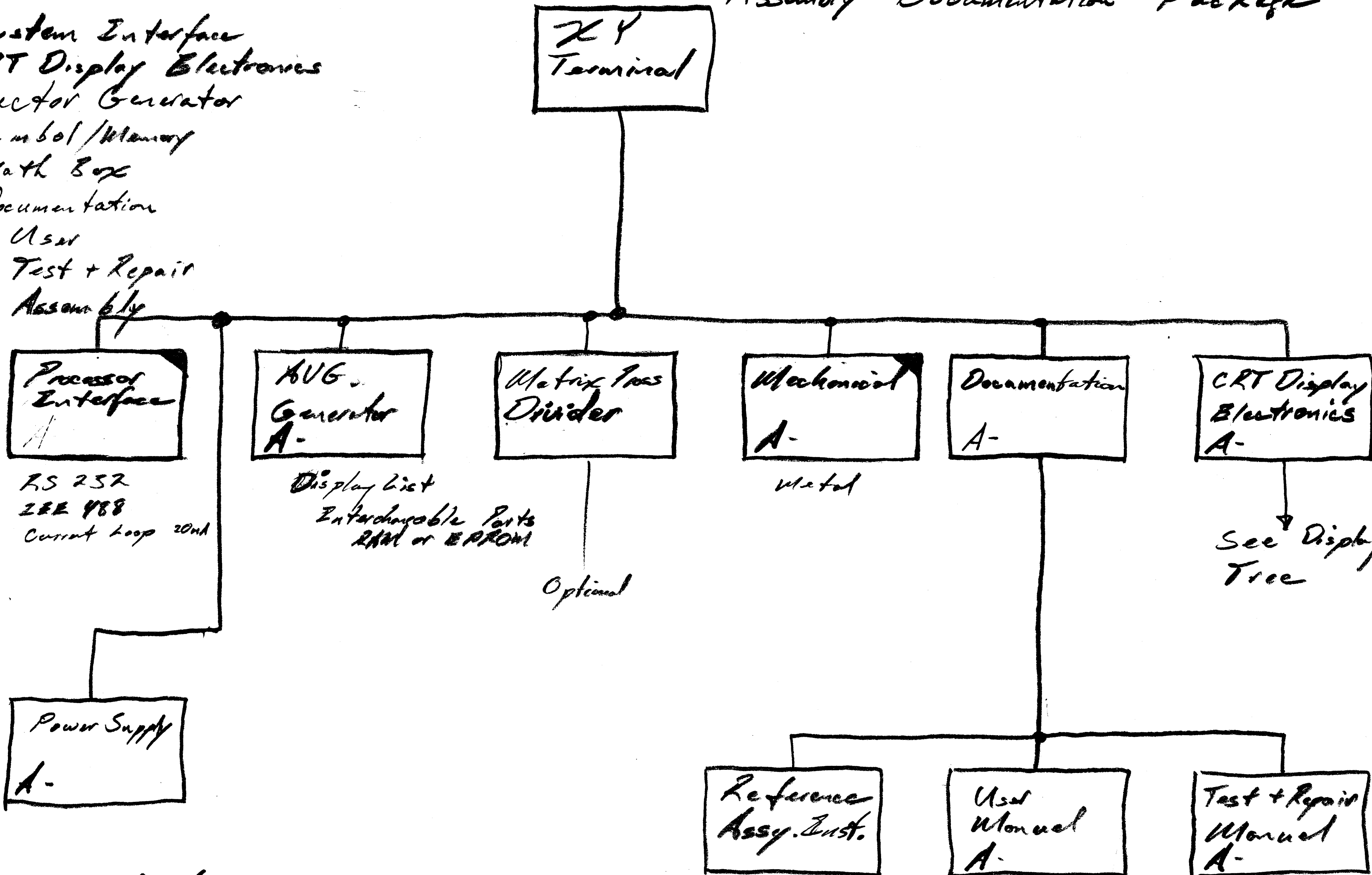
E. Probable people - Karl Von Loewenfeld, Jed Margolin were suggested for certain work.

XY isplay Driver

Assembly Documentation Package

Major Elements

System Interface
CRT Display Electronics
? Vector Generator
? Symbol/Memory
? Math Box
Documentation
User
Test + Repair
Assembly



Baud
110
↓
9600

Self test Asteroids

12/14/81

Display Commands

1. Create Object <u>NAME</u>
   Point List & including center point
2. Create Object Connection List <u>NAME</u>
   square or pyramid Point to Point &
3. Initialize Unit Vectors <u>NAME</u>
4. Roll __° Pitch __° Yaw __° Object __
5. Place Object __ at coordinates __
   Wrap or not
6. Read Back X __ Y __ Z __ Unit Vectors
7. Set Field of View for Perspective Divide
8. Set Object Blanking Distance
   observer to center of object
9. Which Object Viewer is In
10. Setup List of Objects to View
11. Define Two D Stamp <u>NAME</u>
12. Set Scale for Stamps <u>Name</u>
13. Place Stamp __ at coordinates __
14. Move Stamps ΔX __ ΔY __
15. Call Dot generation Routine

12/11/81

ROM Pgm Self Test

The question of ROM command pgm or disk command pgm — to be resolved

HURLE PRISER, MGR 4444 OPS/TA
THOMAS HILTON, ENG LUKE AFB, AZ 85309
Ph (602) 935-6522

STAND ALONE VIDEO TERMINAL

- o PARALLEL INPUTS (16 BITS)
- o FEEDBACK POSSIBLE 16 BITS for cursor
- o OPERATE FROM DISPLAY LIST (vector style)
- o DISPLAY LIST PROVIDED BY HOST
- o CIRCLE PAINT COMMANDS
- o ROTATE/TRANSLATE SPECIFIC LISTS (SYMBOL SETS)
- o NON DESTRUCT SYMBOLOGY (SPECIFIC LISTS)
- o several intensity levels
- o color desired if raster
- o 512 x 512 PIXEL equivalent
- o 3 or MORE frame buffers
- o circle expand & contract
- o Various CRTS ~~OPTO~~ OPTION (5" — 24")
- o PROGRAMMABLE SOUND GENERATOR (OPTION)
- o BOARD SIZE 12" x 12" MAX - PLUGGABLE
- o REMOTE MONITOR CAPABILITY
- o EXTERNAL VIDEO OVERLAY for circles or fixed background (or 2 SYSTEMS FEED ONE CRT IN PARALLEL)

OR o TIME SHARE VECTOR INPUTS for LISSAJOUS figures

- o YOUR LIMITATIONS DETERMINE THE TRAINER LIMITATIONS (YOU TELL US WHAT OUR TRAINER CAN DO)

Tab - “Market Data”

Inter Office Memo

ATARI®

Coin Operated Games Division

To: Lyle Rains

From: Roy Machamer

Subject: GRAPHIC DISPLAY

Date: 12/30/'81

Preliminary data collected indicates the efforts on the simulators may have led us to a market that fits our capabilities and our future needs - Graphics Displays. Here's a quick review of what I have to date - mostly from MiniMicro Systems.

1980 - Shipped		2.5 Billion
	Commercial	1.28 Billion
	Military/Commercial	1.25 Billion
	US Sales	.97 Billion
	Business	273 Million
	Other	697 Million

Growth expected - 35 - 60% next few years.

Price range of growth $3000. - $35,000.

(All data extracted from a Frost & Sullivan report we do not yet have but will order).

Heavy growth expected in high resolution (4Kx4K) Raster (87.5 million to 1.7 Billion) and Graphic Systems. (20 million to 2.3 billion) over the next 8 years.

In addition to the display, the other support items we could supply are: Controls like track balls, joysticks etc. which are necessary for use.

There are some 40 or more Companies in the business with the lowest price about 2K for low resolution (126 x 128) 13" raster by Intellegent Systems Corporation. Most are in the 10K range.

I think we may have something here !

RM:fvw

CC: Rick Moncrief
Dave Stubben
Steve Calfee

Non-programmable CRT terminals

MALCOLM L. STIEFEL, Contributing Editor

Microprocessors have made these so-called 'dumb' devices smarter—and cheaper—than ever

One would think that non-programmable CRT terminals would be extinct by now, their demise brought on by the advent of the microprocessor, which makes all devices potentially user-programmable. However, it is clear from a quick glance at the product table that the non-programmable terminal is thriving. It is no longer news to learn that a computer terminal—or any peripheral, for that matter—runs under control of a micro. In fact, only a handful of currently available units use custom-designed logic chips instead of a micro. In a market where cost competition has reached a fever pitch, manufacturers must respond quickly when competitors announce terminals with lower prices or more functions. The best way to retain this flexibility is to re-program the microprocessor.

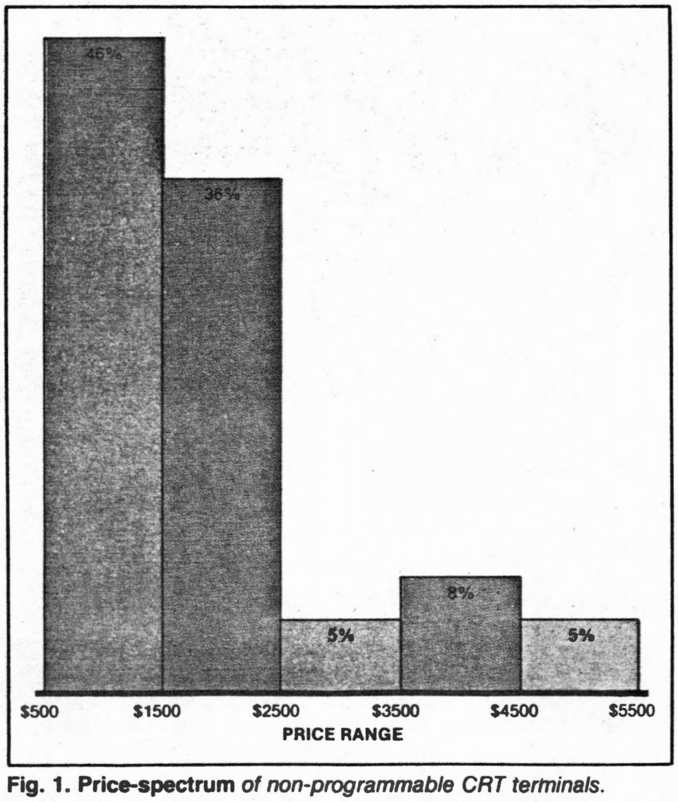


Fig. 1. Price-spectrum *of non-programmable CRT terminals.*

As a result, the functional capability of terminals has reached the point where very few truly "dumb" terminals remain on the market. Almost every unit in the table offers cursor control, a way of highlighting important information, and some built-in editing functions. Still, the prices continue to erode. Almost half the terminals in the survey sell for less than $1500, and more than 80 percent cost less than $2500.

This article will review the characteristics of non-programmable CRT terminals, with emphasis on the functional capabilities that make these devices so fascinating.

Configurations

A typical non-programmable CRT terminal consists of a CRT display, built-in controller, a keyboard, and a communications line interface (Fig. 2). In addition, many terminals also incorporate ports to other devices, such as printers, magnetic card readers, tape cassettes, and bar-code readers (Fig. 3). Most units reside on a desktop or pedestal, but some are portable (Fig. 4) or even hand-held (Fig. 5).

Most non-programmable CRTs are tied to a host computer directly or through a communications line. In applications where dozens of terminals must interact with a host, the terminals are connected to a controller, which, in turn, interfaces with the host. This clustered arrangement requires fewer host I/O ports, and can reduce the load on the host if the cluster controller has some data-manipulation capability.

The primary interface is usually a serial asynchronous arrangement, using the RS-232 standard or the

familiar 20 mA current loop. Most terminals support both full-duplex and half-duplex communications. Some terminals support one of the popular synchronous protocols, such as the IBM binary synchronous communication protocol, or the Honeywell VIP protocol. In the most prevalent approach to synchronous communication, the terminal emulates another terminal that operates under the given protocol. For example, the Racal-Milgo System 400 emulates the IBM 3270 and 2260, the Univac 100/200, and the Honeywell VIP 7700.

The display itself typically includes 24 lines of 80 characters each, although some units accommodate as many as 40 lines (Ann Arbor 4080 COMPAT, Fig. 6) and 132 columns (Datagraphix 132A). Other terminals are more conservative with display space. The Burroughs TD730, for example, displays only eight lines and 32 columns.

Most terminals use a dot matrix to form characters, although there are mavericks like the Datagraphix 132A, which uses a stencil-like mask to form characters. All vendors supply upper-case letter fonts, and several vendors also furnish lower-case letters with descenders, so that the lower-case letters are easily distinguishable. In addition, terminals are available with foreign-language character sets, and graphics characters that enable lines to be drawn on the screen. Moreover, terminals such as the ADDS Regent series can display control characters as well as alphanumerics, effectively transforming the terminal into a line monitor.

All of these functions are tied together in the microprocessor-based controller, which handles communication with the display, the keyboard, and the interfaces.

Cursor control

All CRT terminals have cursors to indicate the position on the screen where the next entry will be made. They also include controls to enable the operator or the computer to move the cursor up, down, left, and right. These functions are vital to the terminal's operation: the user would be severely hampered without them. For example, a cursor enables the user to go back to an earlier entry to make a change, or to skip a field or a line that need not be changed.

Most terminal keyboards include a separate set of cursor-control keys. A user can also position the cursor via the SPACE bar (move right), the BACKSPACE key (move left), the line feed key (move down a line), and the carriage-return key (move to the beginning of the current line). (In some systems, the carriage return also produces a line feed.) There is no way to move the cursor upward without a special key. In any event, the CR, LF, SPACE, and BACKSPACE keys should not be used merely to position the cursor, because they transmit characters to the host. The action of the cursor-control keys, on the other hand, is not conveyed to the host.

The cursor-control set usually includes tab keys to speed horizontal movement of the cursor. In some terminals, tab settings are wired in certain columns (e.g., every eighth column), while in others any column can be defined to accept a tab stop, as in an ordinary typewriter. A unique twist is added in some units: a TAB N action that moves the cursor forward or backward N columns from its initial position. Backward tabbing, a standard feature in many non-programmable terminals, is not found in typewriters, of course.

A feature that has been made practical by the microprocessor is the use of multiple cursors on different segments of the screen, each separately controllable. In the Delta Data 7100, for example, the operator can enter data on one screen segment while data is being transmitted to an auxiliary printer from another segment.

Highlighting

Probably the most effective way to draw a user's attention to an item on the screen, or to help him distinguish between one field and another, is through

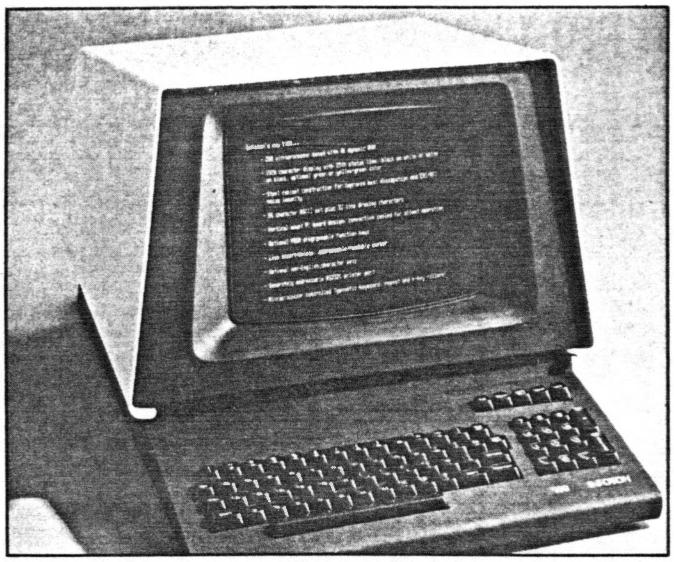


Fig. 2. The model I-100 CRT *terminal by Infoton, Inc.*

the use of color. There are several color terminals on the market, but none of them, surprisingly, is in our table. It appears that all of the color sets go into user-programmable terminals.

But the designers of non-programmable terminals have found other methods of highlighting—not as dramatic as color, but acceptable:

- **Reverse video** to distinguish between titles of fields and the variables within the fields
- **Blinking** to draw the operator's attention to important data or an error message
- **Underline** to give emphasis to certain fields or to separate titles from data
- **Dual intensity** to distinguish between titles and variables.

A few vendors also offer double width characters for highlighting specific fields. Another standard feature, also usually identified as a highlighting capability, is the use of *blanking*—the keying of data which does not appear on the screen. This feature is particularly applicable in log-on procedures, where the user must

TABLE OF NON-PROGRAMMABLE CRT TERMINAL SUPPLIERS

The following tables are provided as a guide to finding vendors of non-programmable CRT terminals. They were prepared by the staff of *Mini-Micro Systems* from its own sources. Some suppliers may not be included, either because they did not respond to our survey questionnaire or responded too late to be included.

MANUFACTURER	MODEL	CONFIGURATION	SCREEN SIZE (hxw)	DISPLAY CAPACITY (cols.&rows)	SYMBOL MATRIX SIZE	CURSOR CONTROL	HIGHLIGHT FEATURES	EDIT FUNCTIONS	FORMAT CONTROL
ALANTHUS DATA COMMUNICATIONS CORP.	V-201	stand-alone	12" diagonal	80 x 24	5 x 7	from computer	reverse video	insert/delete character and line	protected fields
	V-202	stand-alone	12" diagonal	80 x 24	5 x 7	from computer	reverse video; blinking; dual intensity	insert/delete character and line	
	V-203	stand-alone	12" diagonal	80 x 24	5 x 7	none	none	none	none
	V-100		12" diagonal	80 x 24, 132 x 14	7 x 9	none	reverse video; blinking; underline	none	none
ANN ARBOR TERMINALS INC.	400E	stand-alone	8" x 10"	80 x 24 40 x 24 40 x 12	7 x 7	from keyboard; from computer	blink; half-intensity; reverse video	none	none
	531E	stand-alone	8" x 10"	80 x 24 40 x 24	7 x 7	from keyboard; from computer	blink; half-intensity; reverse video	Character or line insert & delete; erase line or page	protected formats stored formats
	4080-Compat	stand-alone	8" x 10"	80 x 40	7 x 8	from keyboard; from computer	blink; half-intensity; reverse video	none	none
	VT52-Compat	stand-alone	8" x 10"	80 x 24	7 x 7	from keyboard; from computer	blink; half-intensify; reverse video	erase to end of line; erase to end of page	none
APPLIED DIGITAL DATA SYSTEMS INC.	Regent 20	stand-alone	12" diagonal	80 x 24	5 x 8	from keyboard; from computer	none	none	none
	Regent 25	stand-alone	12" diagonal	80 x 24	5 x 8	from keyboard; from computer	none	none	none
	Regent 40	stand-alone	12" diagonal	80 x 24	8 x 8	from keyboard; from computer	zero and half intensity; reverse; blink; underline	insert or delete line	non-protected
	Regent 60	stand-alone	12" diagonal	80 x 24	8 x 8	from keyboard; from computer	zero and half intensity; reverse; blink; underline	insert and delete character; insert and delete line	protected format
BEEHIVE INTERNATIONAL	DM10	stand-alone	6.5" x 8.5"	80 x 25	8 x 8	from keyboard; from computer	none	none	none
	DM1A	stand-alone	6.5" x 8.5"	80 x 25	8 x 8	from keyboard from computer	reverse video; blinking; underline; half intensity	none	protected fields
	DM20	stand-alone	6.5" x 8.5"	80 x 25	8 x 8	from computer from keyboard	reverse video blinking underline half intensity	insert/delete character and line; erase field, to end of line, to end of page; clear screen	protected fields
	DM30	stand-alone	6.5" x 8.5"	80 x 25	8 x 8	from keyboard from computer	reverse video blinking underline half intensity	insert/delete character and line; erase field; erase to end of field, line, and page	protected fields stored formats
BURROUGHS CORP.	TD830	stand-alone	6" x 9"	80 x 24; 40 x 24 (double width characters)	5 x 7	from keyboard; from computer	blink underline high intensity reverse video	insert/delete character and line; line move; clear to end of line and page; search for error characters	protected fields
	TD730	stand-alone	8.4" x 4.7"	40 x 12; 32 x 8	5 x 7	from keyboard; from computer	blink	insert/delete character and line; line move; clear to end of line and page; search for error characters	protected fields
DATA GENERAL CORP.	Dasher D1	—	12" diagonal	80 x 24	5 x 7	from keyboard from computer	blink	text editing	host program

KEYBOARD STYLE	SPECIAL FUNCTION KEYS	LINE INTERFACE	LINE SPEED	COMM MODES	COMPATIBILITY	PERIPHERALS	PRICE	COMMENTS
teletype	numeric pad; cursor control	RS-232; 20 mA current loop	110 to 9600 baud			serial printer output	$1650	
typewriter	numeric pad; 19 control keys; 16 function keys	RS-232; 20 mA current loop	110 to 9600 baud	half- and full-duplex		serial printer output	$1820	
typewriter	none	RS-232; 20 mA current loop	75 to 19,200 baud	full- and half-duplex		serial printer output	$860	
typewriter	numeric pad	RS-232	50 to 19,200 baud	full duplex		serial printer output	$1575	displays upper and lower case characters with descenders.
teletype	numeric pad; cursor keys; 36 separate function keys	RS-232; 20 mA current loop	110 to 9600 baud	asynch; full-dup; half-duplex	teletype	none	$1200	
teletype	numeric pad; cursor keys; 12 to 36 function keys	RS-232; 20 mA current loop	110 to 9600 baud	asynch; full- and half-duplex	teletype	output ports for four devices	$1500	upper and lower case characters
typewriter	numeric pad; cursor keys; 36 function keys	RS-232; 20 mA current loop	110 to 19,200 baud	async; full- and half-duplex	teletype	none	$1595	
typewriter	numeric pad; cursor keys; 8 to 36 function keys	RS-232; 20 mA current loop	110 to 9600 baud	asynch; full- and half-duplex	teletype; DEC VT52	none	$1400	
typewriter	cursor control	RS-232, 20 mA current loop	110 to 9600 baud	asynch, full- and half-duplex	teletype	outputs to serial peripherals	$995	upper/lower case characters with descenders; displays 32 ASCII control characters
typewriter	numeric pad, cursor control;	RS-232, 20 mA current loop	110 to 9600 baud	asynch, half- and	teletype	outputs to serial peripherals	$1095	upper/lower case characters with descenders; displays 32 ASCII control characters
typewriter	numeric pad, cursor control, 8 functions, erase	RS-232, 20 mA current loop	110 to 9600 baud	asynch; half- and full duplex	teletype	bi-directional serial port	$1400	upper/lower case characters with descenders; displays 32 ASCII control codes
typewriter	numeric pad, cursor control, erase, insert and delete, 8 function keys	RS-232, 20 mA current loop	110 to 9600 baud	asynch, full- and half-duplex	teletype	bidirectional serial port	$1795	upper/lower case characters with descenders; displays 32 ASCII control codes
typewriter	numeric pad	RS-232; 20 mA current loop	110 to 19,200 baud	asynch, full- and half-duplex	—	—	$995	line drawing capability; displays upper and lower case characters with descenders
typewriter	numeric pad; cursor control; 12 function keys	RS-232; 20 mA current loop	110 to 19,200 baud	asynch; full- and half-duplex	—	—	$1395	line drawing capability; displays upper and lower case characters with descenders
typewriter	numeric pad, cursor control, system mode control, 16 function keys	RS-232, 20 mA current loop	110 to 19,200 baud	asynch; full- and half-duplex		bidirectional port	$1695	line drawing capability; displays upper and lower case characters with descenders
typewriter	numeric pad, cursor control, system mode control, 16 function keys	RS-232, 20 mA current loop	110 to 19,200 baud	asynch; full- and half-duplex	—	serial bidirectional port, parallel interface to Centronics printer	$1995	line drawing capability, displays upper and lower case characters with descenders; display memory 3840 characters (two pages)
typewriter, data entry	numeric pad, cursor control, editing, function keys	—	up to 38,400 baud	synch, asynch	—	printer, tape cassette, magnetic card reader	—	display memory of 2000 to 4080 characters; communications buffer of 1200 to 3000 characters; concurrent data entry on one page and transmittal of another page is permitted
typewriter; data entry	numeric pad cursor control, editing, function keys	—	up to 38,400 baud	synch, asynch	—	printer, tape cassette, magnetic card reader	—	display memory of 2000 to 4080 characters; communications buffer of 1200 to 3000 characters
teletype	numeric pad, editing, cursor control, 8 function keys	RS-232, 20 mA current loop	110 to 9600 baud	asynch, full duplex	teletype	hard copy interface	$1990	

MANUFACTURER	MODEL	CONFIGURATION	SCREEN SIZE (hxw)	DISPLAY CAPACITY (cols.&rows)	SYMBOL MATRIX SIZE	CURSOR CONTROL	HIGHLIGHT FEATURES	EDIT FUNCTIONS	FORMAT CONTROL
DATA GENERAL CORP.	Dasher D2	—	12" diagonal	80 x 24	5 x 8	from keyboard; from computer	blink; underscore; dual intensity	text editing	host program
	Dasher D3	—	12"	80 x 24	5 x 8	from keyboard; from computer	blink; underscore; dual intensity block fill; reverse video	insert, delete; move words, characters, or blocks	protected stored
DATAGRAPHIX, INC.	132-1	stand-alone or cluster	5½" x 10"	132 x 25	charactron (character mask)	from keyboard from computer	dual intensity blink	none	none
	132A, 132B	stand-alone or cluster	8" x 11"	132 x 30	charactron (character mask)	from keyboard from computer	dual intensity	insert and delete character; insert and delete line	protected format
DATAPOINT CORP.		local cluster; remote cluster	12" diagonal	80 x 24	5 x 7	from computer	none	none	none
DELTA DATA SYSTEMS CORP.	2830	stand-alone	15" diag.	80 x 28	7 x 9	from keyboard, from computer	reverse video, underline, blink, blank, negative page, bright and underline	extensive	stored formats
	7100, 7300	stand-alone	15" diagonal	80 x 28	7 x 9	from keyboard, from computer	reverse video, blank, half intensity, underline	insert/delete character and line; clear memory; clear to end of line and memory; search for argument	protected fields stored formats
DIGI-LOG SYSTEMS, INC.		stand-alone	5" diagonal	80 x 16; 40 x 16 (double width characters)	5 x 7	from keyboard, from computer	blink	none	none
DIGITAL EQUIPMENT CORP.	VT100 series	stand-alone	6¾" x 9⅞"	80 x 24, 132 x 14	7 x 9	from computer or keyboard	split screen, underlining, reverse video, blinking	character delete	stored formats
GRUNDY TERMINALS INC.	7000 series	stand-alone	8" x 11"	80 x 24	6 x 8	from keyboard or computer	reverse video, blinking, split screen, underscore	delete to end of line	protected
HAZELTINE CORP.	1420	stand-alone	6" x 9"	80 x 24	5 x 8	from keyboard; from computer	dual intensity, blinking, blanking	clear field and screen	—
	1500	stand-alone	6" x 9"	80 x 24	7 x 10	from keyboard, from computer	reverse video, dual intensity	insert/delete line; clear to end of line and page; clear screen	—
HEWLETT PACKARD CO.	HP2621A, HP2621P	—	6" x 8½"	80 x 24	7 x 9	from keyboard, from computer	underline	insert/delete character and line	none
HONEYWELL INFORMATION SYSTEMS	VIP7100	stand-alone	12" diagonal	80 x 12	5 x 7	from keyboard	none	none	none
	VIP7200	stand-alone	12" diagonal	80 x 24	5 x 7	from keyboard, from computer	dual intensity	erase line erase page	none
	VIP7760	cluster	12" diagonal	24 x 80	7 x 9	from keyboard, from computer	blinking	insert/delete character and line	protected fields stored format
	VIP7700R	stand-alone	12" diagonal	80 x 24	5 x 7	from keyboard, from computer	none	insert/delete character and line	protected fields
	VIP7801	stand-alone	12" diagonal	80 x 25	7 x 9	from keyboard; from computer	reverse video low intensity blinking underline	insert/delete character and line; erase to end of field and end of page	protected fields
	VIP7802	stand-alone	15" diagonal	80 x 25	7 x 9	from keyboard from computer	reverse video low intensity blinking underline	insert/delete character and line; erase to end of line and end of page	protected fields

KEYBOARD STYLE	SPECIAL FUNCTION KEYS	LINE INTERFACE	LINE SPEED	COMM MODES	COMPATIBILITY	PERIPHERALS	PRICE	COMMENTS
typewriter	numeric pad, editing, cursor control, 11 function keys	RS-232, 20 mA current loop	110 to 9600 baud	asynch, full duplex	teletype	hard-copy interface	$2290	
typewriter	numeric pad, cursor control, 18 function keys	RS-232, 20 mA current loop	up to 19,200 baud	asynch, full duplex	teletype	printer interface	$2590	
typewriter	numeric pad, cursor control	RS-232	300 to 19,200 baud	asynch, full- and half-duplex	teletype	cluster controller	$2150	
typewriter	cursor control, editing, numeric pad; 12 function keys (132B)	RS-232	110 to 9600 baud	asynch, full- and half-duplex	teletype	cluster controller, printer interface	$3950	Buffer memory of 60 to 120 lines —
typewriter	numeric pad	RS-232	110 to 9600 baud	asynch, full duplex	teletype	printers	$1950 to $2200	
typewriter	numeric pad	—	—	—	Burroughs TD830, teletype	—	$2500	intended for use in multidrop networks that use Burroughs computers and terminals
typewriter	numeric pad, cursor control, editing, 45 function keys	RS-232	up to 19,200 baud	asynch, synch, half-duplex	teletype	printer, floppy disk	$3200	
teletype	teletype functions	RS-232, 20 mA current loop	50 to 9600 baud	asynch, full- and half-duplex	teletype	serial printer output	$1995	upper/lower case characters; built-in accoustic coupler
typewriter	set up key, scroll select, numeric pad, cursor control	RS-232, 20 mA current loop	50 to 19.2K baud	asynch, full duplex	VT-52	none	$1900	—
typewriter or teletype	numeric pad, cursor control, edit, repeat, scroll, 14 special function keys	RS-232, current loop	50 to 19K baud	sync, async, half-, full-duplex	teletype, Honeywell VIP, DEC VT-100, VT-52, LS ADM-3, Hazeltine	printer, floppy disk, monitor	$800 (in 40-unit quantities)	—
typewriter	numeric pad, cursor control, function keys	RS-232	up to 9600 baud	asynch; full- and half-duplex	teletype	—	$995	—
teletype	numeric pad	RS-232, 20 mA current loop	up to 19,200 baud	asynch, full- and half-duplex	teletype	—	$1225	—
typewriter	numeric pad, cursor control	RS-232	up to 9600 baud	full duplex	teletype	printer	$1450 to $2550	—
typewriter	none	RS-232	9600 baud	full duplex	teletype	none	$1500	—
typewriter	numeric pad, cursor control, 7 function keys	RS-232	9600 baud	asynch, full-duplex	teletype	none	$1980	—
typewriter	numeric pad, cursor control, editing	RS-232	9600 baud	synch	Honeywell VIP protocol	—	$1750 (CRT) $16,800 (controller)	—
typewriter	numeric pad; cursor control	RS-232	9600 baud	synch	—	none	$3990	—
typewriter	numeric pad, cursor control, editing, 12 function keys	RS-232	19,200 baud	asynch, full-duplex	—	none	$2885	line drawing capability
typewriter	numeric pad, cursor control, editing, 12 function keys	RS-232	19,200 baud	asynch, full-duplex	—	none	—	line drawing capability

MANUFACTURER	MODEL	CONFIGURATION	SCREEN SIZE (hxw)	DISPLAY CAPACITY (cols.&rows)	SYMBOL MATRIX SIZE	CURSOR CONTROL	HIGHLIGHT FEATURES	EDIT FUNCTIONS	FORMAT CONTROL
HONEYWELL INFORMATION SYSTEMS	VIP7804/05	stand-alone and cluster	12" and 15" diagonal	80 x 25	7 x 9	from keyboard from computer	reverse video low intensity blinking underline	insert/delete character and line; erase to end of field and end of page;	protected fields
HUMAN DESIGNED SYSTEMS	Concept APL	stand-alone	6" x 9"	80 x 25	9 x 7	from keyboard from computer	reverse video blink underline half bright	insert/delete character; clear to end of line or page; insert/delete line	protected and unprotected fields
	Concept 100	stand-alone	6" x 9"	80 x 25	9 x 7	from keyboard from computer	reverse video blink underline half bright	insert/delete character; clear to end of line or page insert/delete line	protected and unprotected fields
INFORMER	D301	cluster	5" x 5"	32 x 16; 64 x 16	5 x 7	from keyboard from computer	blinking	none	protected fields
	D304	cluster	8" x 9"	80 x 24; 64 x 16; 40 x 12; 32 x 16	7 x 9	from keyboard from computer	reverse video blinking dual intensity	insert/delete character; erase line; erase to end of screen	protected fields stored formats
INFOTON, INC.	Infoton 400	stand-alone	12" diagonal	80 x 25	9 x 7	from keyboard from computer	reverse video half/full intensity, underline; blink	insert/delete character or line; erase line, field or screen; back-tab; forward tab	protected and unprotected fields; numeric-only fields
	Infoton 100	stand-alone	12" diagonal	80 x 25	5 x 9	from keyboard from computer	reverse video half/full intensity	insert/delete line; back-tab; forward tab; erase screen or line; non-destructive space advance	—
LEAR SIEGLER, INC.	ADM-3A	stand-alone	12" diagonal	80 x 24	5 x 7	from keyboard from computer	none	insert and delete character	none
	ADM-31	stand-alone	12" diagonal	80 x 24	7 x 11	from keyboard from computer	reduced intensity reverse video blink blank underline	insert/delete character and line; erase to end of line, field, and page	protected fields stored formats
	ADM-42	stand-alone	15" diagonal	80 x 25	7 x 11	from keyboard from computer	reduced intensity reverse video blinking underlining	insert/delete character and line; erase to end of line or field or page	protected fields; stored format
MEMOREX CORP.	1377-4	stand-alone and cluster	9¼" x 12¼"	80 x 25	7 x 11	from keyboard from computer	reverse video	insert/delete character	none
MICROFORM DATA SYSTEMS INC.	—	stand-alone and cluster	12" diagonal	80 x 25	8 x 10	from keyboard from computer	reverse video blinking dual intensity	insert/delete character	protected fields stored formats up to 8K bytes
NORTHERN TELECOM SYSTEMS CORP.	297	local or remote cluster	9" x 12"	80 x 24	7 x 9	from keyboard from computer	tri-intensity	insert/delete character	protected format
PERKIN ELMER CORP.	—	local cluster	7" x 10"	80 x 24	5 x 9	from computer	reverse video	none	none
	550 Bantam	stand-alone	12" diagonal	80 x 24	5 x 9	from keyboard from computer	reverse video	none	none

KEYBOARD STYLE	SPECIAL FUNCTION KEYS	LINE INTERFACE	LINE SPEED	COMM MODES	COMPATIBILITY	PERIPHERALS	PRICE	COMMENTS
typewriter	numeric pad, cursor control, editing, 12 function keys	RS-232	19,200 baud	synch, full-duplex	—	none	—	line drawing capability
typewriter paired APL	numeric pad, cursor control, function keys	RS-232, 20 mA current loop	50 to 9600 baud	asynch, full- and half-duplex	teletype	up to three devices	$1365 to $1750	APL character set; three user-specifiable character sets
typewriter	numeric pad, cursor control, special functions	RS-232, 20 mA current loop	50 to 9600 baud	asynch, full- and half-duplex	teletype	up to three devices	$1230 to $1575	three user-specifiable character sets
typewriter	numeric pad, cursor control, 2 function keys	RS-232, 20 mA current loop	50 to 9600 baud	asynch, half- and full-duplex	—	none	$700 to $850	—
typewriter	numeric pad, cursor control, 28 function keys	RS-232	50 to 19,200 baud	asynch, full- and half-duplex	teletype	printer output, bar code reader, light pen	$855 to $1695	—
—	numeric pad, cursor control, 8 function keys	RS-232, 20 mA current loop	50 to 19,200 baud	asynch, full- and half-duplex	teletype, Hazeltine 2000	serial or parallel printer interface	—	line drawing capability
—	numeric pad, cursor control, edit functions	RS-232, 20 mA current loop	110 to 19,200 baud	asynch, full- and half-duplex	teletype, DEC VT52, Hazeltine 1500, ADDS520, LSI ADM-3A	printer port	—	limited graphics capability
typewriter	none	RS-232, 20 mA current loop	75 to 19,200 baud	asynch, full- and half-duplex	teletype	printer output	$895	—
typewriter	numeric pad, cursor control, editing, page forward	RS-232, 20 mA current loop	50 to 9600 baud	asynch, full- and half-duplex	teletype	printer output	$1450	two pages of memory
typewriter	numeric pad, edit, cursor control, 16 function keys, page forward and backward	RS-232, 20 mA current loop	50 to 9600 baud	asynch, synch, full- and half-duplex	teletype	printer output	$1795	two to eight pages of memory; line drawing capability
typewriter, data entry	numeric pad, cursor control, editing, function keys	—	up to 19,200 baud	—	IBM 3277-2	printer	$3800	—
typewriter	numeric pad, cursor control, editing, 32 function keys	RS-232	300 to 9600 baud	asynch, full-duplex	—	microfilm display terminal	$4275 (one station), $5990 (dual station)	—
typewriter, data entry, keypunch	numeric pad, cursor control, program function	RS-232	1200 to 9600 baud	synch, full- and half-duplex	IBM 3270	60 to 180 character per second serial printer, light pen, badge reader	$2240 (CRT), $2760 to $9200 (controller), $3840 (printer)	—
typewriter	numeric pad	RS-232, 20 mA current loop	110 to 9600 baud	asynch, full- and half-duplex	teletype	printer	$599 to $966	—
typewriter	none	RS-232, 20 mA current loop	110 to 9600 baud	asynch, full- and half-duplex	teletype	printer	$599	—

MANUFACTURER	MODEL	CONFIGURATION	SCREEN SIZE (hxw)	DISPLAY CAPACITY (cols.&rows)	SYMBOL MATRIX SIZE	CURSOR CONTROL	HIGHLIGHT FEATURES	EDIT FUNCTIONS	FORMAT CONTROL
PERKIN ELMER CORP.	1200 OWL	stand-alone	12" diagonal	80 x 24	9 x 12	from computer from keyboard	reverse video half intensity blinking	insert/delete character and line; Clear all; clear non-protected; clear line/field	protected fields local storage
RACAL-MILGO, INC.	System 400	stand-alone	5.75" x 10.5"	80 x 24	7 x 11	from keyboard from computer	reverse video blinking half intensity	insert/delete character and line; insert word	protected format
	40+MPL	stand-alone	5.75" x 10.5"	80 x 24	7 x 11	from keyboard from computer	reverse video blinking half intensity	insert/delete character, line, and word	protected format stored format
TEC, INC.	571 and 572	stand-alone	6" x 9"	80 x 25	5 x 7	from keyboard from computer	reverse video reduced intensity blinking underline blank video	insert/delete character and line; erase to end of line and field	protected format alpha-only fields numeric-only fields
	500 series	stand-alone	6" x 9"	80 x 25	5 x 7	from computer from keyboard	reverse video	erase to end of line	none
	70-C	stand-alone	6" x 9"	80 x 25	5 x 7	from keyboard from computer	blinking reduced intensity reverse video blanking	insert/delete character and line; erase to end of line and field	protected format
TELETYPE CORP.	4540 series	remote cluster	5¼" x 11¼"	80 x 24	7 x 9	from keyboard from computer	three intensity levels blinking	insert/delete character and line; clear screen	protected format
TERMIFLEX CORP.	HT Series	stand-alone	2" x 4"	12 x 1; 20 x 1; 6 x 2; 10 x 2; 12 x 2; 20 x 2; 20 x 4	5 x 7	from keyboard	blinking	insert/delete character	none
TERMINAL DATA CORP.	675	stand-alone	9" and 15" diagonal	64 x 16	5 x 7	from keyboard	underline	none	none
	700	—	9" and 15" diagonal	80 x 24	5 x 7	from keyboard from computer	underline	insert/delete character and line	protected format
TNR, INC.	XJ-25	stand-alone	9½" x 7½"	80 x 24	9 x 12	from keyboard from computer	reverse video blinking dual intensity	insert/delete character and line; erase to end of line and screen	protected format
VECTOR GRAPHIC, INC.		stand-alone	12" x 12"	64 x 16; 80 x 24	7 x 9; 8 x 10	from computer	reverse video reduced intensity	insert/delete character and line	stored format
	Mindless Terminal	local cluster	7¼" x 9½"	64 x 16; 80 x 24	5 x 7; 7 x 9	from keyboard from computer	reverse video reduced intensity	—	—
VISUAL TECHNOLOGY INC.	Visual 200	stand-alone	12" diag.	80 x 24	7 x 9	from keyboard or computer	dual intensity, blinking, blanking	insert/delete character and line; clear to end of line, field, or page; clear line or screen	protected fields
WESTERN UNION DATA SERVICES	Video-100	stand-alone	7" x 10"	80 x 24	5 x 7	—	none	none	none
	Video-200	stand-alone	7" x 10"	80 x 25	5 x 7	from keyboard from computer	reverse video blinking underline half intensity	insert/delete character and line; erase field and page	protected formats
ZENTEC CORP.	ZM550	stand-alone and cluster	8" x 10½"	80 x 25	7 x 9	from keyboard from computer	dual intensity underline blanking double width characters	insert/delete character and line move block	protected fields stored formats

KEYBOARD STYLE	SPECIAL FUNCTION KEYS	LINE INTERFACE	LINE SPEED	COMM MODES	COMPATIBILITY	PERIPHERALS	PRICE	COMMENTS
typewriter	mode control, printer control, numeric pad, cursor control, edit, 32 function keys	RS-232, 20 mA current loop	75 to 9600 baud	asynch, full- and half-duplex	teletype	printer	$1361 to $2195	
typewriter	numeric pad, cursor control, editing, repeat, function keys	RS-232	50 to 9600 baud	asynch, synch, full- and half-duplex	IBM 3270, 2260; Univac 100/200; Honeywell VIP 7700	160-cps 200-lpm printer	$4550 to $4950	
typewriter	numeric pad, cursor control, editing	RS-232	50 to 2400 baud	asynch, synch, full- and half-duplex	teletype	240-cps printer	$4585 to $5030	
typewriter	numeric pad, cursor control, editing, 7 function keys	RS-232, 20 mA current loop	50 to 19,200 baud	asynch, full- and half-duplex	teletype	printer	—	
typewriter	numeric pad	RS-232; 20 mA current loop	50 to 9600 baud	asynch, full- and half-duplex	teletype, Lear Siegler ADM-3A, ADDS Consul 580, Regent 100	serial printer	$954	
typewriter	numeric pad, cursor control, editing, function keys	RS-232, 20 mA current loop	50 to 9600 baud	asynch, full- and half-duplex	teletype	printer	$3010	integral magnetic stripe reader reads Internation Air Transport Assoc. standard cards.
typewriter, data entry	numeric pad, cursor control, editing, 12 function keys	RS-232	2400 to 9600 baud	synch, half-duplex	IBM 3270	line printer, badge reader	$1700 (CRT) $520 (keyboard) $5464 (controller for 32 CRTs)	—
20-key pad	none	RS-232, 20 mA current loop	110 to 2400 baud	asynch, full- and half-duplex	—	none	$495 to $3995	hand-held unit
teletype	none	RS-170; RS-232	110 to 9600 baud	asynch; full- and half-duplex	teletype	printer	$695	—
teletype	none	RS-170, RS-232	300 to 19,200 baud	asynch, full- and half-duplex	teletype	printer	$995	—
typewriter	function keys; repeat key	RS-232	19,200 baud	asynch, full- and half-duplex	—	none	$697	—
typewriter	numeric pad, cursor control, directional control	—	110 to 9600 baud	asynch	—	—	$625	memory-mapped video
typewriter	numeric pad, cursor control	S-100 bus	—	—	—	—	$765 to $805	memory-mapped video
typewriter	cursor control, edit, numeric pad, 14 function keys, scroll	RS-232, 20 mA current loop	110-19.2K baud	async, half-, full-duplex	Hazeltine 1500, ADDS 520, LS ADM-3A, DEC VT-52	serial I/O port	$1195	rear-panel switch selects terminal to be emulated; smooth scroll
typewriter	cursor control	RS-232, 20 mA current loop	75 to 19,200 baud	asynch; full- and half-duplex	teletype	printer output	$860	—
typewriter	numeric pad, cursor control, editing, function keys	RS-232, 20 mA current loop	50 to 19,200 baud	asynch, full- and half-duplex	teletype	printer output	$1850	—
typewriter	numeric pad, cursor control, editing, function keys	RS-232	110 to 19,200 baud	asynch, synch, full- and half-duplex	teletype	printer	$1600	up to 8 pages of display memory

The functional capability of non-programmable terminals has reached the point where very few truly 'dumb' terminals remain on the market.

enter a password, but does not wish the whole world to see it on the screen. The blanking capability is a necessity in time-sharing systems with many users. Not all terminals offer highlighting, and some include only one or two highlighting functions.

Unlike control characters, which occupy display memory space, highlighting attributes are "free" to the user, in many cases. For example, in the Beehive International DM20, each memory word includes highlight data bits, individually settable by the computer or the operator. Thus, a single character may be displayed in reverse video, underlined, blinking, and at half intensity all at once.

Editing

Every terminal on the market has a text editing capability, although it is limited in scope in the less-powerful terminals. For example, it is possible to replace a character by another in a line of text. In more advanced terminals, it is also possible to insert or delete a character with the remainder of the text closing up or shifting accordingly. If the insert and delete functions were not présent, correcting an error would require the operator to retype the remainder of the text following the error, a tedious procedure if the error affects several lines of text. Some terminals have additional editing commands that enable a block of text or an entire screen to be erased with a single keystroke. This, too, relieves the operator of the tedium of having to clear the affected data character-by-character with the space bar.

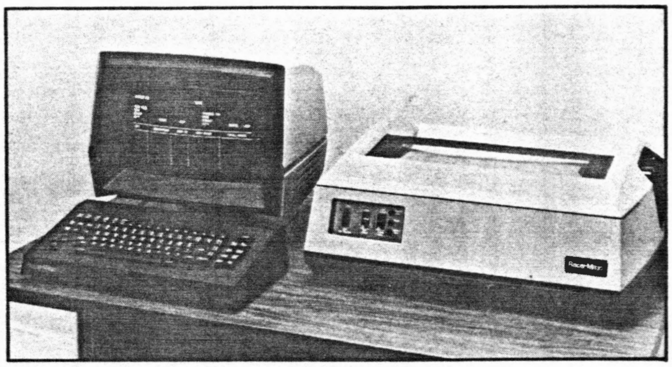


Fig. 3. The Racal-Milgo *model 400/3 work station.*

Still another editing feature, found in only a few models, is the ability to move a line of text up or down, exchanging it with the line above or below it on the screen. This is a handy feature in publishing applications and in word-processing terminals.

Format control

Format control is essential if the terminal is to be used in data-entry applications. The user defines *protected fields* on the screen that will contain titles, and *unprotected fields* that will contain variables. The format of the unprotected fields can be further restricted to, say, numeric only or alpha only, or left zero fill, thereby facilitating error detection.

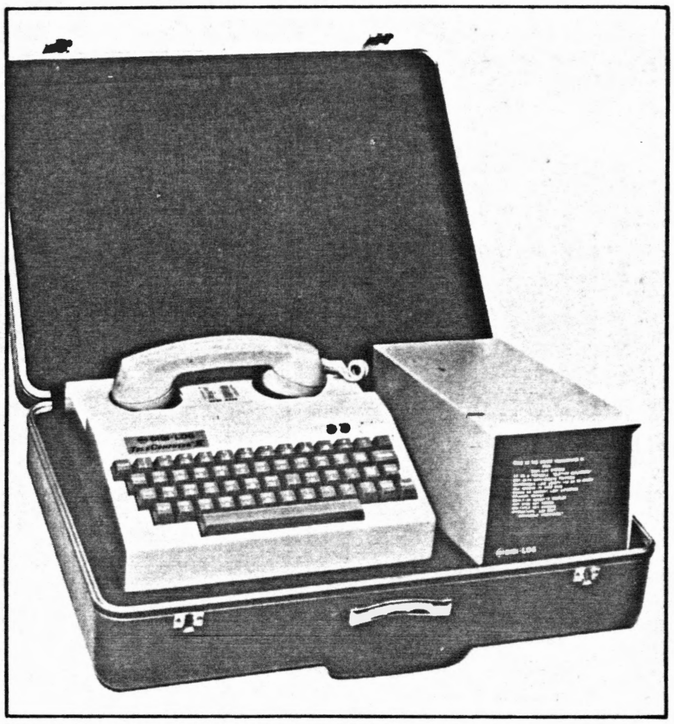


Fig. 4. Portable CRT *terminal by Digi-Log Systems Inc.*

In some terminals, several formats can be stored in the terminal memory, to be called up as needed. However, terminal memory is limited in capacity and is volatile—contents are lost when power is removed. For this reason, formats are usually stored in the host computer or in a tape cassette unit attached to the terminal. Then the user retrieves the format for use as the need arises.

Formats are usually defined in *pages*—display memory segments of a fixed length. A typical page size is equal to the display screen capacity. Thus, on an 80 × 24 screen, the page size will be 1920 characters. However, some terminals allow more freedom in setting page size. For example, in the Burroughs TD730, a page can be as little as four lines long. If the screen holds N pages, the format is defined once, but it appears on the screen N times.

In data entry, cursor movement is restricted to the unprotected fields. In the Burroughs TD730, further restrictions may be imposed at the user's discretion. If he wishes, the cursor may be frozen at the end of the page, not moving onto the next page until another command is entered. Similarly, the cursor may be frozen at the end of each field until a skip or tab action is taken. This guards against the entry of extraneous characters in a field that would overflow onto the next field if the cursor movement were not restricted.

Function keys

In their specifications, vendors draw a distinction between garden variety function keys on the keyboard

Cursor control functions are vital to the operation of a terminal. Surprisingly, there are no non-programmable color terminals on the market.

and *programmable* function keys. When an ordinary function key is depressed, it sends a short predetermined character sequence, such as ESC 3 CR or SOH F, to the host. The character sequence is designed to be unique—it is not expected to ever occur in other traffic between the terminal and the host—so that the host can recognize it and respond accordingly. In a system with several such keys, each key is associated with its own unique character sequence.

The programmable key may be used in a similar manner. In this case, the character sequence is defined by the user through the terminal, but it is much longer—31 to 63 characters in the Lear Siegler ADM 42—and it needn't be unique. It can be used to insert constants in the text or to define message headers or other strings that will be repeated frequently in a particular application.

The use of the programmable key is taken a step further in the Delta Data 7000 series, where a sequence of up to 256 characters may consist not only of messages to the host but commands to the terminal itself (Fig. 7).

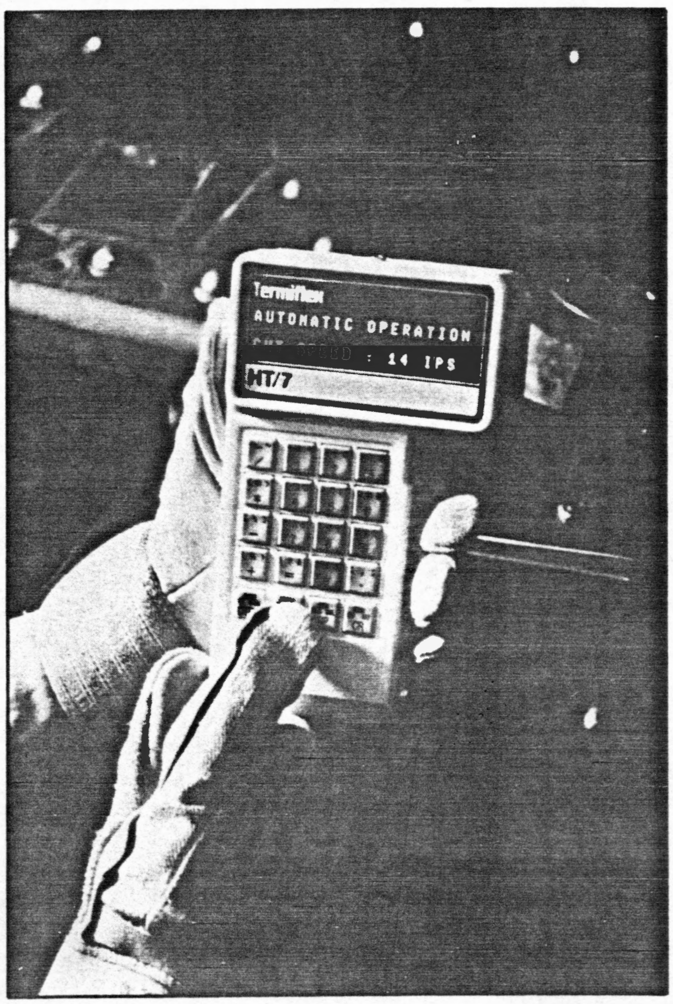


Fig. 5. The Termiflex *hand-held terminal.*

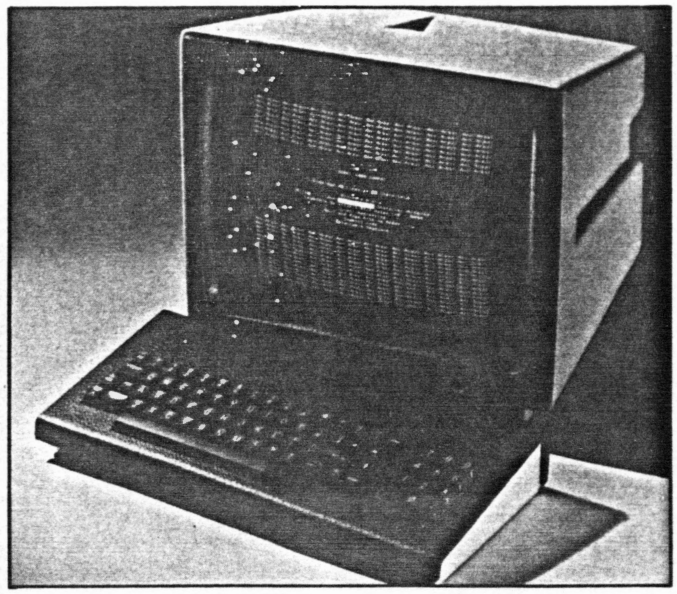


Fig. 6. The model 480-Compat *terminal by Ann Arbor Terminals, Inc.*

For example, such a sequence can be used to move a block of text from one part of the screen to another, move the cursor to another predetermined position, and initiate a transmission to the host all at the same time.

The programmable function key relieves the host of some burden that it might encounter in handling a short cryptic character sequence that must be interpreted. It also occupies more bandwidth on the communication line, so the system designer must examine the merits of both approaches before choosing the function key for a particular application.

Transmission control

Transmission from the terminal to the host occurs in any of three modes:

- **Conversational.** A message is transmitted a character at a time as it is keyed in;
- **Line.** One display screen line at a time is transmitted;
- **Block.** A full screen's worth of data or a block comprising several lines is transmitted.

There are several important variations of the block transmission mode, including:

- **Unprotected.** Transmit only data in unprotected fields;
- **Protected.** Transmit only data in protected fields (used in defining a format to the host);
- **Changed.** Transmit only data in unprotected fields that has changed since the last transmission.

Presumably, this last mode, in which only changed data is transmitted, is very efficient, because it places a minimal burden on the communication line. Unfortunately, it places a substantial burden on the host. The changed field must identify itself to the host, so that it can be processed. Also, each field in such a format must carry a unique identifier, which consumes display memory space. Transmitting all unprotected fields is a much sounder idea, because the message can then

assume a fixed format that is easily interpreted by the host.

Some terminals also offer "data compression," another feature of dubious value. In this case, the system suppresses trailing space characters in alphanumeric fields, inserting a delimiter such as tab instead. This process also reduces the message length because it eliminates characters, but it produces variable-length messages that must be scanned by the host, character by character, to reconstruct the original data in the terminal. This added host overhead may more than offset any advantages gained in transmission time.

Searching the display memory

In basic units, display memory is limited to the capacity of the display, but in more advanced models, memory capacity is several times the screen capacity, reaching as much as 28,000 characters. In such large-capacity systems, the operator needs some assistance in finding specific items of information. The Burroughs TD830 incorporates a search mode, allowing the cursor to jump to positions containing error-character codes so that the operator can make the necessary corrections.

Such an automatic searching capability is unusual. For the most part, the user is expected to use rolling and scrolling controls to move the data past the cursor one line at a time so that the user may examine it. There is a fine distinction between rolling and scrolling. In both rolling and scrolling, the cursor remains fixed in position, while the lines of data move up or down the screen, at the operator's discretion, for examination. In rolling, the lines in one page are moved. In scrolling, all of the lines in memory are moved, as though they were written on a continuous sheet.

Fig. 7. This Delta 7000 ***terminal is intended to be used in text editing applications.***

Trends

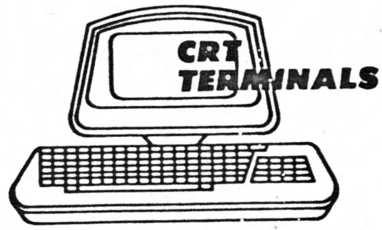
The non-programmable CRT terminal may outlast the programmable terminal, continuing to drop in price and improve in functionality. The programmable terminal will become so powerful, eventually, that it will be considered a small computer system, rather than a terminal. In contrast, the non-programmable terminal will retain its identity. Memory sizes will increase, of course, as some of the newer chips find their way into terminal display memories. And the really "dumb" terminals will disappear, unable to compete with their more capable counterparts, which handle cursor control, editing, and the rest with ease. ■

REFERENCE LITERATURE

For more information on the non-programmable CRT terminals surveyed in this article, use the reader circle numbers listed below.

Company	Circle No.
Alanthus Data Communications Corp., Rockville, Md	401
Ann Arbor Terminals Inc., Ann Arbor, Mich	402
Applied Digital Data Systems Inc., Hauppauge, N.Y.	403
Beehive International, Salt Lake City, Utah	404
Burroughs Corp., Detroit, Mich	405
Data General Corp., Westboro, Mass	406
Datagraphix, Inc., San Diego, Calif.	407
Datapoint Corp., San Antonio, Texas	408
Delta Data Systems Corp., Cornwells Heights, Pa.	409
Digi-Log Systems, Inc., Horsham, Pa	410
Digital Equipment Corp., Marlboro, Mass	411
Grundy Terminals, Inc., San Diego, Calif	412
Hazeltine Corp., Greenlawn, N.Y.	413
Hewlett-Packard Co., Palo Alto, Calif	414
Honeywell Information Systems, Inc., Waltham, Mass	415
Human Designed Systems, Philadelphia, Pa.	416
Informer, Inc., Los Angeles, Calif	417
Infoton, Inc., Burlington, Mass	418
Lear Siegler, Inc., Anaheim, Calif	419
Memorex Corp., Santa Clara, Calif.	420
Microform Data Systems, Inc., Mountain View, Calif	421
Northern Telecom Systems Corp., Ann Arbor, Mich	422
Perkin-Elmer Corp., Randolph, N.J.	423
Racal-Milgo, Inc., Miami, Fla	424
TEC, Inc., Tucson, Ariz	425
Teletype Corp., Skokie, Ill	426
Termiflex Corp., Nashua, N.H.	427
Terminal Data Corp., Rockville, Md	428
TNR, Inc., Willow Grove, Pa	429
Vector Graphic, Inc., Westlake Village, Calif	430
Visual Technology Inc., Andover, Mass.	431
Western Union Data Services Co., Mahwah, N.J.	432
Zentec Corp., Santa Clara, Calif.	433

MAL STIEFEL, now on the technical staff at Mitre Corp., has worked as a systems analyst, systems engineer, and programmer on military command and control systems, hospital administration, investment securities, and municipal information systems.



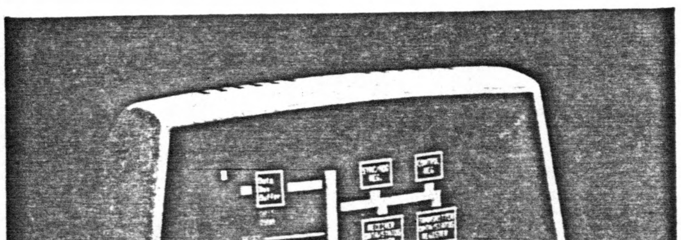
Providing terminal comfort

CATHERINE RAFTERY & JOHN KEENER, Lear Siegler, Inc.

The modern terminal can't offer eternal peace, but it can be most accommodating

It has been said that when it comes to finding tools and appliances that are easy to use, nobody has to search longer than a left-hander. There is another larger group, however, that may have an even more valid claim on the title of "Forgotten Consumer." Anyone whose physical proportions and capacities are not quite average has occasionally experienced the discomfort of working with implements that are not quite right. Why? They were engineered for the "average" user—that special breed who is not nearly as numerous as designers have believed. Only recently have developers and manufacturers of computer equipment—especially CRT terminals—begun to realize that if their product is to be used by a variety of operators, it must be adjustable to each individual.

The National Institute for Occupational Safety and Health (NIOSH) reports that 5 to 10 million video-display terminals are being used by more than 7 million operators. This tremendous proliferation of CRT units has resulted in concern for the health of those who work with the equipment over prolonged periods. Designing "user-friendly" terminals has become an important consideration for manufacturers and OEMs that integrate the units into their systems. As a result, buyers of these products can now select from an ever-increasing array of terminals engineered specifically for long-term comfort. CRT terminals now have components that detach, tilt, swivel, rotate and respond in various other ways to the needs of the operator.



Lear Siegler's ADM 42 Ergonomic Terminal *console has a 15-in. tiltable screen with an anti-reflective surface, high-resolution monitor controls for contrast and brightness, a tiltable monitor, a detachable keyboard and 32 touch-sensitive screen pads that activate pre-programmed functions.*

Ergonomics—minimizing discomfort

The study of the physiological interaction between

Only recently have developers and manufacturers of computer equipment—especially CRT terminals—begun to realize that if their product is to be used by a variety of operators, it must be adjustable to each individual.

man and machine is called ergonomics. In response to the many ergonomic studies conducted during the past couple of years and the growing demand for products that are comfortable, designers have begun to incorporate features into their CRT terminals that improve operator productivity by minimizing discomfort, error and fatigue. These ergonomic features involve all terminal components, including case, screen, keyboard and electronics. A buyer may not need a terminal loaded with ergonomic features, and should weigh each feature against its price. An occasional user should consider that ergonomically featured products may not be justified. However, in situations in which a terminal is an operator's main tool, comfort is a key concern. The buyer must decide which ergonomic features he must have and which he can do without. If he makes his selections with his own operation in mind, he will probably choose wisely.

Research indicates health problems

NIOSH—the main organization studying ergonomics—found that employees using terminals regularly had far more health complaints than non-users. Visual problems ranked as the most widespread complaint, specifically, blurring, itching and burning eyes. NIOSH discovered that workers trying to compensate for their discomfort often assumed awkward body positions at the screen, resulting in backaches, neck aches and

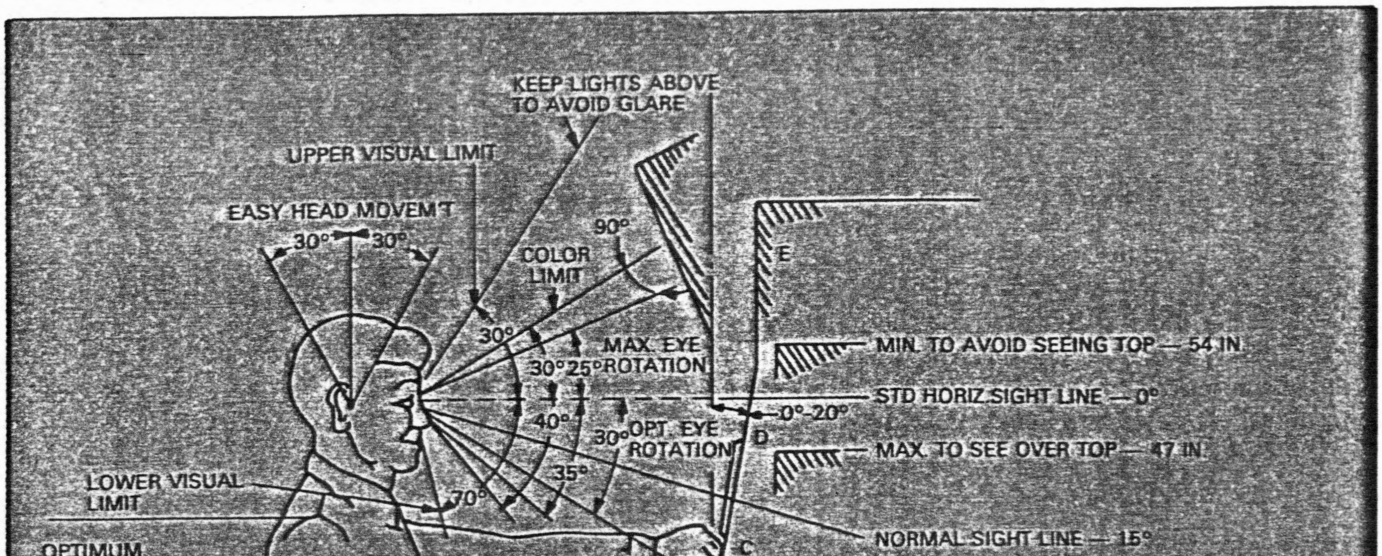


Fig. 1. The ideal ergonomic work station *is one in which everything can be adjusted for maximum efficiency and comfort. Chart is courtesy of Design West, Irvine, Calif., and statistics are from* Measure of Man: Human Factors in Design *(published by Henry Dreyfuss & Associates).*

CRT terminals have received more attention than other equipment because they are an operator's direct link with a computer.

other muscular problems. Fortunately, in all cases, these disorders were only temporary.

Researchers have not determined, however, the exact causes of these health problems. NIOSH concluded that the issue is far too complex to be the fault of the CRT terminal alone. A worker's entire environment—his physical traits, stress threshold, computer experience and the tasks he performs—can contribute to his discomfort. Lighting, angles of the equipment and desk and chair heights are also possible factors (Fig. 1).

Ergonomic Improvements

CRT terminals have received more attention than other equipment because they are an operator's direct link with the computer. This focus on terminals has spurred modifications of three components in particular: the keyboard, the screen and the case.

Keyboards today are detachable to enable users to position them independently of the display to conform to individual spatial requirements. They are also being made heavy enough to prevent sliding during operation, yet light enough to be easily moved.

According to the book *Measure of Man: Human Factors in Design* (Henry Dreyfuss & Associates), keyboard dimensions and organization are almost as important as detachability. There should be 28 cm. from the top of the operator's seat to the tops of the keys. The keyboard should be sloped at a 5- to 15-degree angle, like that of a typewriter. The distance from the base of the keyboard to its home keys should be less than 50 mm.; 30mm. is ideal.

The keys should operate at 0.25- to 1.5-in.-per-lb. pressure. Spacing between adjacent keys is optimal at 18 to 20 mm. to prevent mishits. Catastrophic damage to work can occur, for example, if the break key is accidentally struck. Concave or dished home-row keys with a matte finish to minimize reflections also improve operator accuracy. To avert other errors, certain functions, such as terminal reset, should require a two- or three-key command. Some ergonomic keyboards emit an audible feedback when a key is depressed.

Finally, keyboard organization can help eliminate stress. Most operators are more familiar with the arrangement of a typewriter keyboard than that of a Teletypewriter. Providing a familiar tool eliminates a training step and makes the terminal less intimidating. The same is true for a numeric keypad configured in a calculator layout (7, 8 and 9 in top row) or telephone format (1, 2 and 3 in the top row). When the numeric pad is used for accounting, for example, calculator format is preferable. Function keys should be a different color or shape from the alphanumeric section of the keyboard.

The CRT screen of most video-display terminals is usually fixed at an angle of 10 to 15 degrees from the vertical—ideal for a person of average height. Ergonomically designed terminals, such as Lear Siegler's ADM 32 and ADM 42, offer adjustable screen tilt, usually from 5 degrees forward to 15 degrees backward. Research indicates that operators should be able to position their line of sight within 15 degrees of a terminal's central axis. A rotatable screen is also helpful when an operator must move about while entering data.

The properties of a screen are critical if visual problems are to be averted. Ergonomic terminals incorporate features to offset glare and flicker as well as to improve character quality.

Anti-reflective properties can be built into a CRT screen. Coatings, plastic panels and etching reduce glare from the polished glass of standard CRT faceplates. If the phosphor of the display screen has a long persistence, a user may see trails after the characters; too short a persistence causes flickering.

Some terminals offer variable-brightness control. If the screen offers only dual intensity, however, a user should make sure that both levels can be read without difficulty.

High-quality character display should be a priority in terminal selection. Characters generated by dot matrix, for example, should merge individual dots closely enough to produce a well-defined image. The width of the characters should be approximately 70 to 80 percent of upper-case-character height, and the space between characters should be between 20 to 50 percent of character height. Row space is optimal at 100 to 150 percent of character height. There should be a marked distinction between similar characters, such as X and K, O and Q, T and Y, S and 5, I and L and U and V; O and 0 are often hard to differentiate. In addition, the cursor should be a conspicuous part of the display.

The cabinets of ergonomic terminals are also undergoing changes to include an overhang above the display, which prevents screen glare, and a front-edge keyboard-housing extension on which an operator can rest his hands.

As video-display terminals become increasingly commonplace in the office, it becomes more important for the units to be both unobtrusive and attractive—much like a telephone or typewriter. The terminal should be small enough to require minimum desk space and should be a neutral color to blend with a variety of environments. The case should have a matte finish to minimize glare, its material should be textured to hide wear and scratches, and its keycaps should be a dark color to conceal fingerprints. Finally, openings in the terminal should be kept as small as possible to reduce the likelihood of tiny objects falling into the unit's electronics.

Certain terminal functions, intended for ease of use, can be considered ergonomic features. These include

As video-display terminals become increasingly commonplace in the office, it becomes more important for the units to be both unobtrusive and attractive—much like a telephone or typewriter.

editing, visual attributes, function keys and operator-feedback features such as a status line.

Today's terminals offer a broad range of editing capabilities. Some conversational terminals, such as Lear Siegler's ADM 5, allow erasure only to the end of the line or page, while smart terminals, such as Lear Siegler's ADM 32, offer complete editing.

Some applications require visual attributes—blinking, blanking, underlining or reverse video. If the primary purpose of a system is forms-data entry, visual attributes make an operator's job much easier. Constant data can be displayed in one video mode, while variable data is entered in a highlight mode. Like editing capabilities, various levels of video-mode features are available. Some low-cost terminals offer one or two of the visual attributes, while more costly terminals provide all of them.

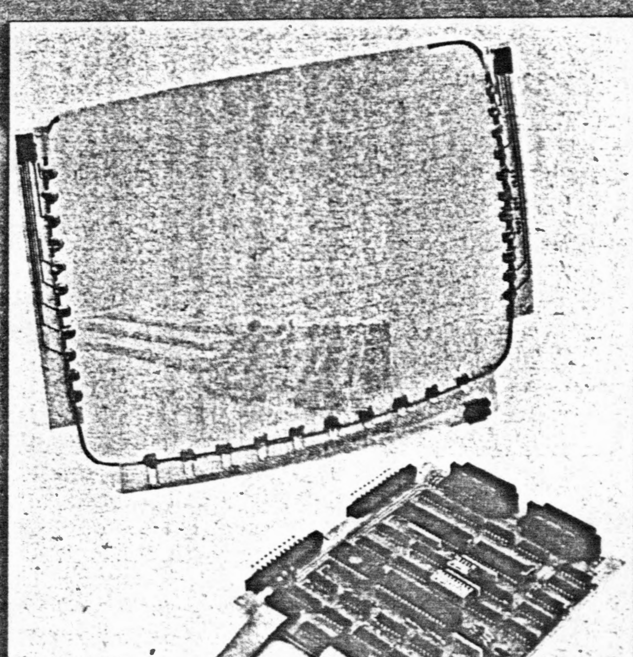
Whenever an operator can enter the same data with one key instead of several, productivity is improved. Programmable function keys permit this. If a job involves a phrase or data string, it can be stored in function-key memory so that every time a function key is actuated, a string of characters will be generated.

Two new technologies that make operation of video-display terminals easier by limiting or eliminating the use of a keyboard are voice-recognition and touch-sensitive screen terminals. Both are useful for non-typists and novice computer-users because they don't require typing to access important data. These technologies, formerly prohibitive in price, are now available in low-cost packages.

Voice technology. Forecasters expect the U.S. market for speech-recognition products to be $100 million by 1984, up from $10 million in 1980. Voice data entry is useful whenever the operator is entering data and performing a second task concurrently. Some potential applications include inventory control, quality-control inspections, shipping and receiving inspection, order entry (such as airline reservations and sales orders) and data recording in scientific laboratories.

The advantages of voice technology are significant: a dramatic reduction in operator training time and error, faster data-entry time and reduced operating costs. According to Interstate Electronics Corp., a leading manufacturer of speech-recognition equipment, a skilled word-processing operator takes approximately three months to learn the command structures for a new word-processing system. The same operator can learn the material in two days using automatic voice recognition.

There are some limitations to voice technology, although there have been dramatic improvements since it was first marketed in the early 1970s. At that time, most systems had very limited vocabularies, poor recognition accuracy and exorbitant prices. Today, a user can buy some voice-recognition products for less than $5000—less than half the price of their predeces-



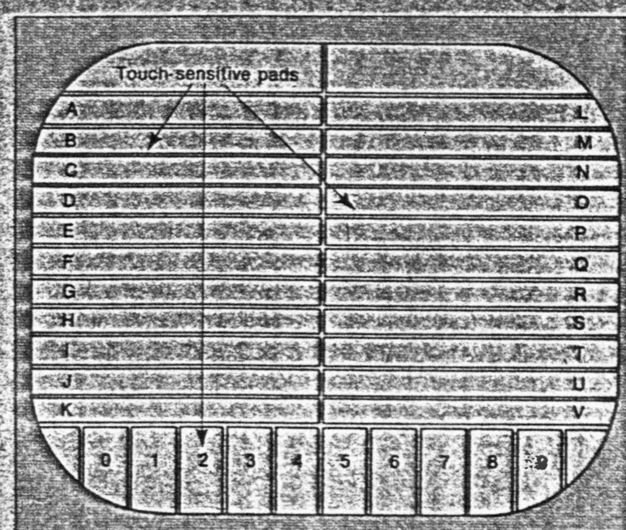


Fig. 2. The touch-sensitive CRT screen has 32 nearly invisible pads (A-V, 0-9) that respond to the touch of a finger so that users can conduct an interactive dialog with the terminal to obtain information from on-line files without any prior training. This unit is from Interaction Systems, Inc., Newtonville, Mass.

Two new technologies that make operation of video-display terminals easier by limiting or eliminating the use of a keyboard are voice recognition and touch-sensitive screen terminals.

sors. Although many still have a vocabulary of only 100 words or so, recognition capability is now better than 99 percent. Most systems are still speaker-dependent, which means that an operator's vocal patterns must be programmed into the computer by repeating the command words or phrases several times. These sounds are then converted into digital codes and stored in computer memory. When a user intones a command, a digital code for the new sound is compared with the stored data until the two signals match (Fig. 2) or verification is achieved.

Touch-sensitive screens. Touch-sensitive screens, like voice recognition, simplify communications with the computer. Touch screens operate with sensitive pads that respond to the touch of a finger (Fig. 2). The screen is activated by a human body's capacitance, which is detected by sensors. In this way, users who are unfamiliar with data-processing equipment can conduct an interactive dialog with a CRT terminal to obtain information from on-line files.

Touch-sensitive capability has applications in perhaps the broadest market of all—the general public. Using a menu-selection mode, these terminals take the video-display terminal into airport-terminal flight directories, hospital-patient data, executive-suite financial analysis, department-store merchandise information, library card catalogs and museum and national-park directories. ■

Catherine Raftery is director of product marketing, and **John Keener** is director of terminal development at Lear Siegler, Inc., Anaheim, Calif.

NEXT MONTH IN MMS

Two major product profiles—surveys of products and trends in two categories—will highlight the feature article section of Mini-Micro Systems in September. They are single-board μcs and analog input/output boards for computer systems

In the first of these, Contributing Editor Mal Stiefel will survey a broad range of single-board μcs that are offered as standard, off-the-shelf products for integration into stand-alone systems, smart terminals, communications processors and other equipment. Extensive tables for product evaluation will accompany the article.

The other product profile will explore the latest developments from builders of board-level units that link digital mini- and microsystems to the analog world. These analog I/O subsystems acquire and convert data such as temperature and pressure for use by a computer.

Which type of terminal is right for you?

THOMAS G. VIGGERS, Lear Siegler, Inc.

The careful buyer will consider how much CRT capability he needs, evaluate vendors and allow for system growth

With more than 50 video display terminal manufacturers producing 200 or more different products, the prospective user faces a complicated task in trying to select both the appropriate terminal for his computer system, and the supplier from whom to purchase it.

The computer industry has established three categories for terminal types: dumb, smart and intelligent. Within each category, there's a vast array of display and keyboard features, plus a myriad of capabilities for editing, communications, memory and programmability in the smart and intelligent categories. And the selection process is more complex than simply identifying the desirable features and choosing the lowest-cost terminal that has them. This article will not offer a solution to each application because there are no set solutions. But there are guidelines that can be followed to help ensure that the decision is the best possible. The OEM must consider the end-user when configuring systems, especially if the OEM is developing application software, and is trying to meet as many end-user requirements in the basic system as possible.

Why a terminal?

Before talking to terminal suppliers, a prospective buyer should analyze the problems he hopes to solve with terminals and should determine his organization's requirements. Is the terminal needed for rapid data entry and retrieval of inventory data, or is it for word processing? Or, will it be used to develop computer programs?

Depending on the user's needs, he may find that video terminals are not the most cost-effective solution. For example, large real estate companies have tried to computerize sales data. When a client comes in to look for a home, the sales person enters all the buyer data into the terminal. The system then responds with the ideal house for that customer. Although the system works well, the sales force may not like it. Installing terminals for that purpose isn't wise.

If the prospective user determines that terminals are the most economical solution and have the greatest long-term advantages for his company or system, he then needs to examine which type of terminal best suits his needs. Does he need dumb, smart, intelligent or a combination? This, of course, depends on his applications, the size of the computer system, the data-processing experience of the users and several other factors. But the user can't intelligently consider the dumb, smart and intelligent terminal categories until he understands the difference among them.

Who are you calling dumb?

The terms dumb, smart, and intelligent were created to give some sense of order to the broad range of available terminals. Any attempts to provide rigid definitions for each category are impossible because

CLASSIFICATION BY MANUFACTURERS

DUMB	SMART	INTELLIGENT
ADDS Regent 20 Beehive Micro B1 Hazeltine 1410 Infoton I100 Lear Siegler ADM-3A Perkin-Elmer Bantam 550 Soroc IQ120	ADDS Regent 60 Beehive Micro B2 Hazeltine 1510 & 1520 Infoton I400 Lear Siegler ADM-31 and 42 Soroc IQ140	Beehive Datapoint Four Phase Ontel Raytheon Sycor
$500 - $1,000	$1000 - $5000	$5000 +

Fig. 1. Terminal *classification by manufacturers.*

Dumb, smart and intelligent categories are defined, and logical applications for each are provided.

exceptions can be found for each statement. It is possible, however, to define them broadly so that the prospective customer can narrow the possibilities.

"Dumb" was first coined by Lear Siegler Inc., as a name for a CRT terminal that had minimum capabilities: the ADM-3A. The term is now accepted as common for all such terminals. At the lowest end, a dumb terminal has a display screen, a keyboard for data entry and a way to communicate with the CPU. It serves as a simple input/output device.

As the market for dumb terminals has grown, manufacturers have added enhancements, such as upper/lower case—as opposed to just upper case—a built-in numeric pad and complete cursor addressing. Because these terminals are designed to be very low cost, they must sell for less than $1000, and sometimes even as low as $500-$600. Terminal models in this category include the ADDS Regent 20, Beehive Micro B1, Hazeltine 1410, Infoton 100, Lear Siegler ADM-3A, Perkin-Elmer Bantum 550 and SOROC IQ120.

THE OUTLOOK IS ANYTHING BUT TERMINAL

Terminal shipments in 1978 amounted to 950,000 units, for a value of $2.4 billion, according to a study conducted by Gnostic Concepts, Inc., Menlo Park, Calif., an electronics market research firm. Most shipments—759,000 units—were of alphanumeric terminals, while of the remainder, 98,000 units were small business computers, 8,000 were video monitors, 11,000 were graphics terminals and 74,000 were special-purpose terminals.

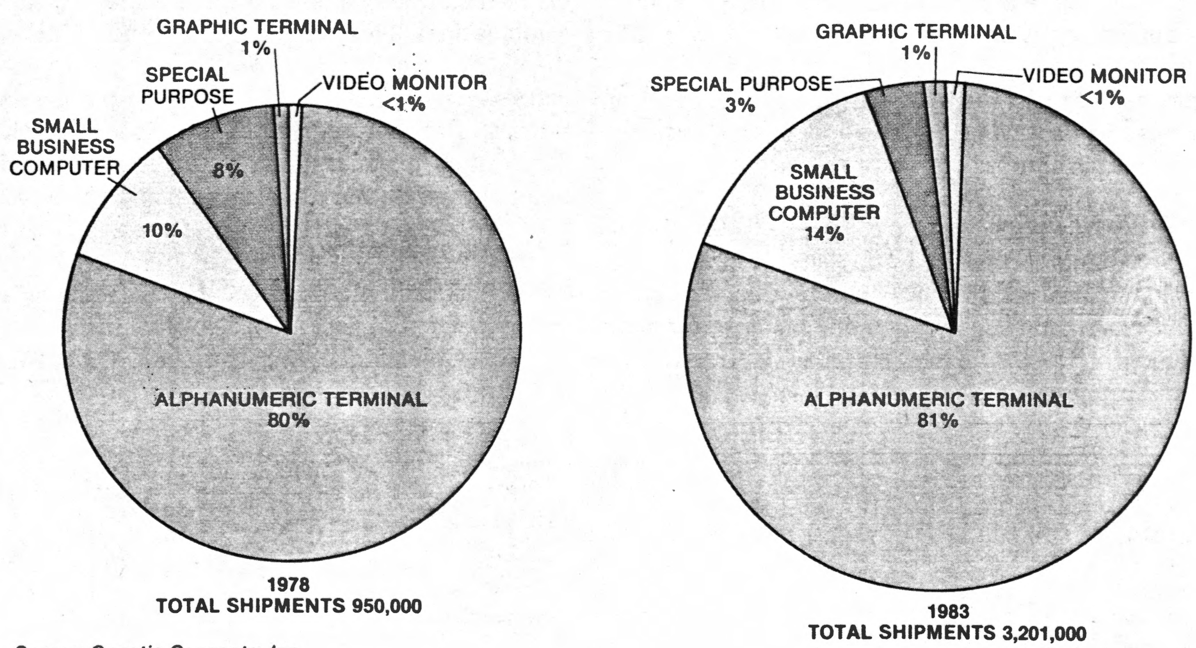
A five-year forecast in that study called for strong growth in shipments, with a gradual decline in price per unit. Shipments will increase at an average rate of 28 percent per year, reaching 3.2 million units by 1983. Prices will drop at an average of 10 percent per year, which will limit the market value of $4.37 billion. The study states that the small-business computer segment will grow at a faster rate than the total CRT market, with a 35 percent annual increase in unit shipments, bringing its share of the market to 14 percent (Fig. 2).

The proliferation of the small-business computer and distributed data processing are boosting dumb and intelligent terminal sales in both OEM and end-user markets, and will continue to do so over the next five years. Dumb terminal sales will grow approximately 25-30 percent because they are cost-effective input/output devices when the CPU in on-site. Future-generation dumb terminals will probably contain fewer components, bringing increased reliability and reduced costs, possibly even heading toward the general consumer level. The industry will also see a high-end dumb terminal at today's prices.

Distributed data processing will be responsible for the 28-30 percent growth of intelligent terminal sales. It will also affect the dumb terminal market because many work stations at remote locations will use some dumb terminals for routine tasks. It has even been predicted that within the next five years, distributed data processing will account for approximately 50 percent of all CRT terminal sales.

Smart terminal sales are estimated to grow only 15 percent this year. This is because some dumb terminals will begin to have smart-terminal features at a lower cost, and also because smart terminals are not dominant in either the small-business or distributed-data-processing segments.

CRT TERMINAL APPLICATIONS



Source: Gnostic Concepts, Inc.

Fig. 2. CRT terminal *applications for 1978 and 1983.*

User applications will go a long way toward selections, especially if users write 'job descriptions' for terminals.

A smart terminal is one in which features have been added to the dumb unit's basic capabilities—up to, but not including, user programmability. These features include visual attributes (blinking, blanking, underline, reverse, dual intensity), block transmission mode, formatting, more sophisticated communications (polling and addressing), additional options (printer interface), editing functions, and screen memory.

A smart terminal has read only memory or programmable read only memory; but the user cannot program applications into it. The latter capability requires random access memory, and puts the terminal into the

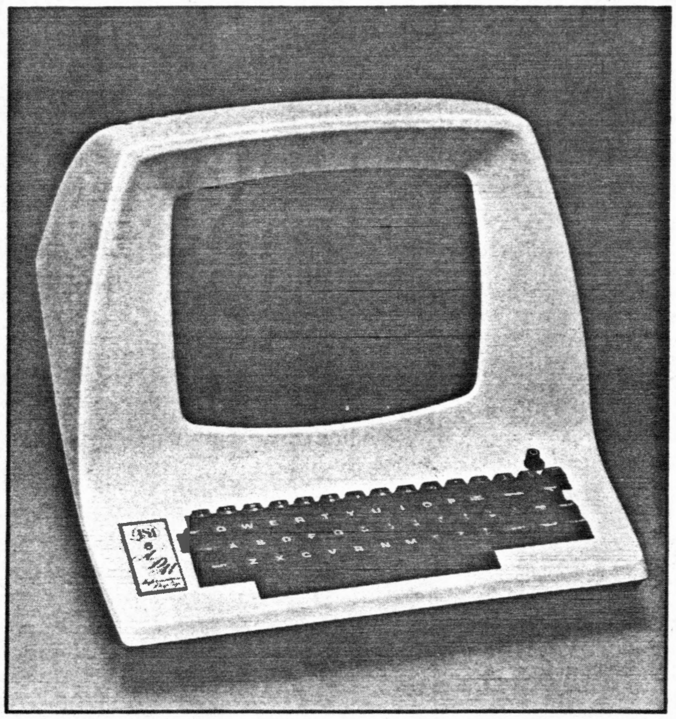


Fig. 3. The classical *dumb terminal is Lear Siegler's ADM-3A.*

intelligent category. Smart terminal prices range from \$1000 to \$5000, although most are less than \$2000. Examples include the ADDS Regent 60, Beehive Micro B2, Hazeltine 1510 and 1520, Infoton I400, Lear Siegler ADM-31 and ADM-42 and SOROC IQ140 (Fig. 1).

User programmability distinguishes intelligent terminals, which include a processor, RAM, and a resident high-level language or assembly language. They can make decisions on their own. Beyond programmability, these terminals also have many of the features included in the smart category. Intelligent terminals can cost \$25,000 or more, and can be as powerful as some minicomputer systems. Manufacturers include Datapoint, Four Phase, Ontel, Raytheon, and Sycor.

Selection criteria

A grasp of the problem to be solved and the three terminal categories leads the prospective buyer to

Fig. 4. Delta Data Systems *model 7300 smart unit has highlighting features, such as reverse video and reverse underlining.*

consideration of a wide range of variables that will affect his selection. Probably the most important criteria for choosing a CRT terminal are related to applications. Essentially, the user has to write a job description for the terminal. What functions will the terminal have? What capabilities does it need to complete those tasks most efficiently? A key factor will be the computer's software. The user will have to decide whether the CPU will be programmed to perform certain smart-terminal functions, or whether the terminal will have those capabilities built in. He must consider, however, that some smart-terminal features—such as blinking, blanking and reverse-visual attributes, and block mode—cannot easily be programmed into the CPU, while the CPU can handle others, including editing and formatting.

In most small-business applications, the user will be performing accounts receivable, accounts payable, payroll and inventory. He can usually buy packaged software so that the applications are built into the computer itself. In that case, a dumb terminal is all he needs. But there are always exceptions. One user may want automatic blinking to indicate customers who are late paying bills, and blinking is a smart-terminal feature. The user must decide whether blinking alone is worth an additional several hundred dollars, especially if he may also have to take several other features he doesn't need. But formatting may also be attractive for accounts receivable. Because formatting is also a smart terminal feature, the investment may be worthwhile.

Word-processing considerations

Word-processing applications always involve text editing, a smart-terminal feature for which the tradeoffs between CPU programming and the terminal's capabilities are an important consideration. If the system is dedicated primarily to accounting functions,

Prospective buyers are wise to check vendor track records and staying power in the market.

for example, the user may not want to burden the computer's memory with editing because he wants to reserve it for the priority accounting applications. A smart terminal is the appropriate choice in this case. But if word processing is the primary application, it is more cost-effective to program the application into the computer and use a less-expensive dumb terminal.

For a system totally devoted to word processing, a cost-effective alternative to a computer is a smart terminal with editing capabilities, plus several pages of memory interfaced to a printer. But the user should also think ahead. He may eventually want to do other applications on the system. If so, buying a complete system now may save money later.

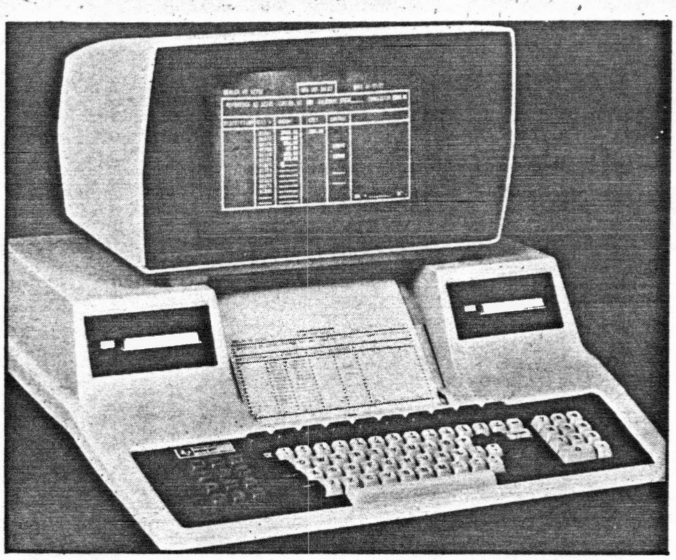


Fig. 5. Model 770 *intelligent terminal from Texas Instruments includes printer.*

On the other end of the scale, a complex application requiring statistical analysis or writing programs may warrant an intelligent terminal. But, here again, it depends on the number of other applications planned for the system, and whether or not the user wants to preserve main memory by doing some processing at the terminal. An intelligent terminal is also appropriate when the job can't be done by a smart terminal; it needs some processing but doesn't require an entire minicomputer system. For example, the user may want the terminal to put forms on the screen automatically and complete extensions for invoicing. If that is the only application, an entire system isn't needed. An intelligent terminal can also be programmed to emulate another terminal for interface purposes.

Size and type of computer operation

Some overlapping occurs between applications and the size and type of computer operation. For example, distributed data processing can be considered both an application and a type of computer operation. There are five basic categories that fall under this heading. They include timesharing; a single-user system consisting of one computer and one terminal; a multi-user system at one facility with several terminals on-line to a CPU; a data-communications network with scattered terminals tying into a central CPU via phone lines; and a distributed data-processing operation in which equipment can range from one remote terminal to entire remote minicomputer systems, all reporting to a host computer at a central location.

Timesharing service bureaus usually have very basic software for commonly-used applications, and are a less-expensive alternative to owning an entire system. The software is built into the bureau's computer. All the user needs, in most cases, is a dumb terminal.

In most single-user minicomputer systems, in which the CPU is on-site, a dumb terminal is sufficient, but this will also depend on applications because, for example, no dumb terminal will blink or transmit in block mode. A multi-user system with several terminals at one location might require a variety of terminal types. It depends on how many people will be using the terminals at the same time and for what applications. If the only application is data entry, dumb terminals are the answer. But if five people need to do text editing, occupying one terminal at all times during the day, one smart terminal for that purpose is appropriate.

Data communications networks present another consideration—the communications lines. The user needs to define his network. A dumb terminal will not function in a high-data-rate polling network. Using many smart terminals probably won't work either, because they must have synchronous capabilities. The user will probably need a network of intelligent terminals based solely on communications.

Distributed data processing involves several factors, including consideration of the communications and the volume of data being processed at remote sites. A small branch office with minimal processing needs should have an intelligent terminal as the sole piece of equipment. That terminal can perform the data-processing tasks, can communicate with other parts of the network and can transmit the data to central headquarters. But a large branch office may warrant an entire remote minicomputer system. In the latter case, a dumb terminal will probably suffice because the CPU is on-site.

It's important to consider who will be using the system. The terminal should support, rather than hinder, employees. A retail clerk's primary function is to be a salesperson. A business person doesn't want to spend a lot of time at a terminal, and wants immediate answers. A dumb terminal is best suited to him. But a university professor who has a big problem in economics may be willing to do whatever it takes to get accurate and comprehensive information. Both the professor and a computer programmer creating a COBOL program may prefer using an intelligent terminal.

But knowing the application and what to look for in terminal features isn't enough. The prospective buyer needs to decide what manufacturer's equipment he wants. By studying what others in his industry are using, and how successful they are, he should get a good idea which vendors to contact. Another approach is to contact research firms that follow the electronics industries. These companies usually have literature on several vendors in the desired terminal category, and can provide unbiased sampling.

At this point, the prospective buyer may be ready to call in suppliers to discuss individual products. He must consider that sales representatives or distributors normally have a biased view. Although he sells many products, the distributor may be trying to sell the most-expensive item and will not offer an objective suggestion. It is also critical to study the candidate vendor and ask: What is its reputation? Will it still be in existence three years hence? What kind of customer support does the company provide? Can it service equipment at the user's locations? The buyer also must ask questions about the stability of the product itself. How long has it been in existence? How many have been shipped? Is there a warranty and for how long? What is the mean-time-between-failure record?

A thorough study of all of these factors, achieved by talking to current users of the equipment, studying the literature and interviewing sales people, should help the prospective buyer to the best decision. ■

THOMAS G. VIGGERS is product marketing manager for video display terminals at Lear Siegler Inc.'s Data Products Division, Anaheim, Calif. He has been involved in applications engineering with the division since 1971.

COMING IN AUGUST

- THE OUTLOOK FOR 8-INCH DISKS
- WANG'S INTEGRATED INFORMATION SYSTEM
- PROGRAMMING ARRAY PROCESSORS
- THE DEC CRT TERMINAL EMULATION MARKET

Package transforms wireframe models into 3-D shaded solids

Applicon's Solids Modeling package, for use with the company's CAD/CAM system, transforms wireframe models created on an Applicon system into color, three-dimensional, shaded solids models by using Digital Equipment Corporation's VAX 11/750 or 11/780 system.

Solids models—realistic representations of designs used to visualize and analyze part geometry before building a prototype—can also be displayed on an Applicon system as wireframes to produce drawings and technical illustrations with hidden lines automatically removed.

A sectioning feature enables designers to "slice away" or cross-section the model to reveal inner components or surfaces. Sectioning may be planar, stepped, rotated, or partial. Because all necessary geometric and spatial information is contained in the model data base, mass properties such as area, weight, volume, moments of inertia, and center of gravity are automatically calculated.

Isometric views, exploded views, detailed dimensioned drawings, assembly drawings, or technical illustrations can be generated from solids models. Information is extracted from the solids model to produce line drawings with hidden lines automatically removed or dashed. Exploded views, orthographic views, isometrics, and section cuts can also be output as solids models to help designers present design ideas or for use in proposals, manuals, and other documentation.

Users interactively create wireframe models on an Applicon system. The wireframes are then transferred to a VAX via DECnet or magnetic tape for processing. Afterwards, solids models may be generated as hard copy or returned to the company's system to create working drawings or technical illustrations.

Solids Modeling interfaces to the company's color plotting system, which creates full-color hard copy up to 22" × 34". The user can also output the line drawing to an Applicon line plotter, or view the solids as wireframe versions, with hidden lines removed, on an Applicon black and white or color design terminal.

Solids Modeling is priced at $50,000. Initial deliveries are scheduled for December.

Reader Service Number 62

System performs graphics functions locally

The VG 33000 distributed graphics-processing system off-loads graphical processing functions normally performed in the host computer and executes them locally in its own dedicated processor. According to the manufacturer, Vector General, the system's distributed architecture can reduce host computer display processing by 50 percent.

Among the functions off-loaded from the host computer are servicing of display interrupt requests, display buffer management, queueing data from interactive devices, matrix concatenations, interactive viewporting, and basic picture editing.

Because so many functions are performed locally, Vector General says, the VG 33000 is the fastest interactive display system on the market. Performance of such basic editing functions as line deletion is instantaneous to the operator, and user response time is equally fast, no matter how many display stations are included in the system, the company says. The VG 33000 can transform 13,500 3-D vectors per 33-ms frame, and its best-case clip-and-zoom time is 0.9 μs at any arbitrary rectangular viewport.

Individual work stations can be located as far as a mile from the host computer and still achieve highly interactive communications rates (one megabit per second with PDP-11 and VAX computers). The architecture supports Digital Equipment Corporation's DDCMP protocol, but the programmable system can interface with any computer via an asynchronous or synchronous serial interface. Without involving the host computer, a VG 33000 operator can modify, add, or delete picture elements, exchange data with other VG 33000 work stations, and develop and debug programs.

The basic VG 33000 configuration consists of an MC 68000 CPU, 32K bytes each of RAM and PROM, 64K bytes of refresh memory (expandable to 256K bytes), a 3-D display generator unit, a high-speed vector generator, a 21-inch high-speed display monitor, depth cueing circuitry, chassis, and power supply.

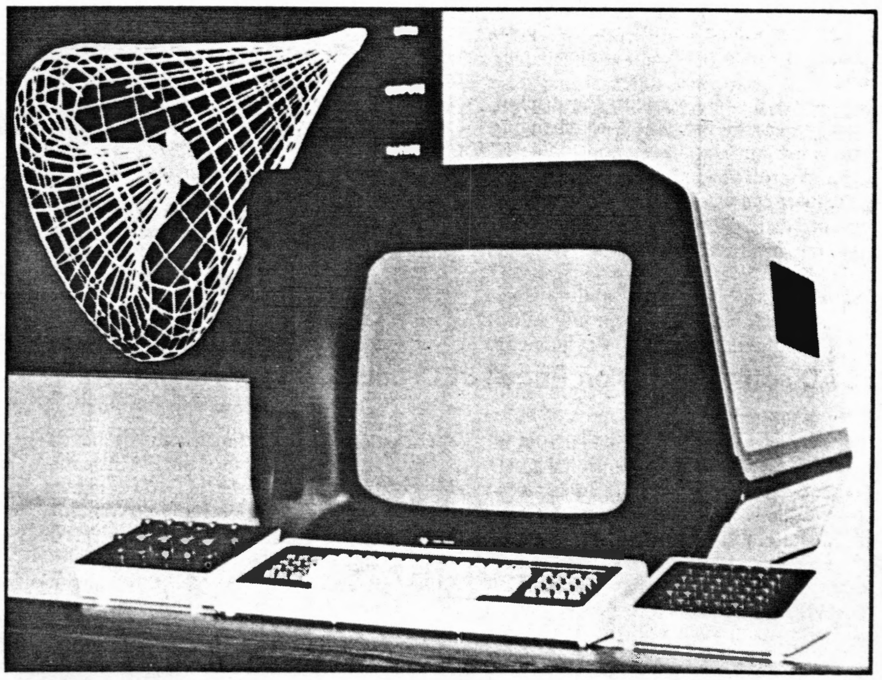
The VG 33000 offers a choice of display capabilities and physical configurations. Features include such input devices as alphanumeric keyboard, data tablet, joystick, lighted function switches, control dials, and light pen; display monitors (monochrome and color) in a range of sizes and speeds; and modular work station furniture.

Other features are 256 programmable intensity levels; absolute, relative, incremental, or autoincremental vectors; and hardware blinking of displayed elements under program control. Hardware facilities include character generation, a variety of line textures, a circle arc generator, scaling, clip, zoom, translation, and rotation.

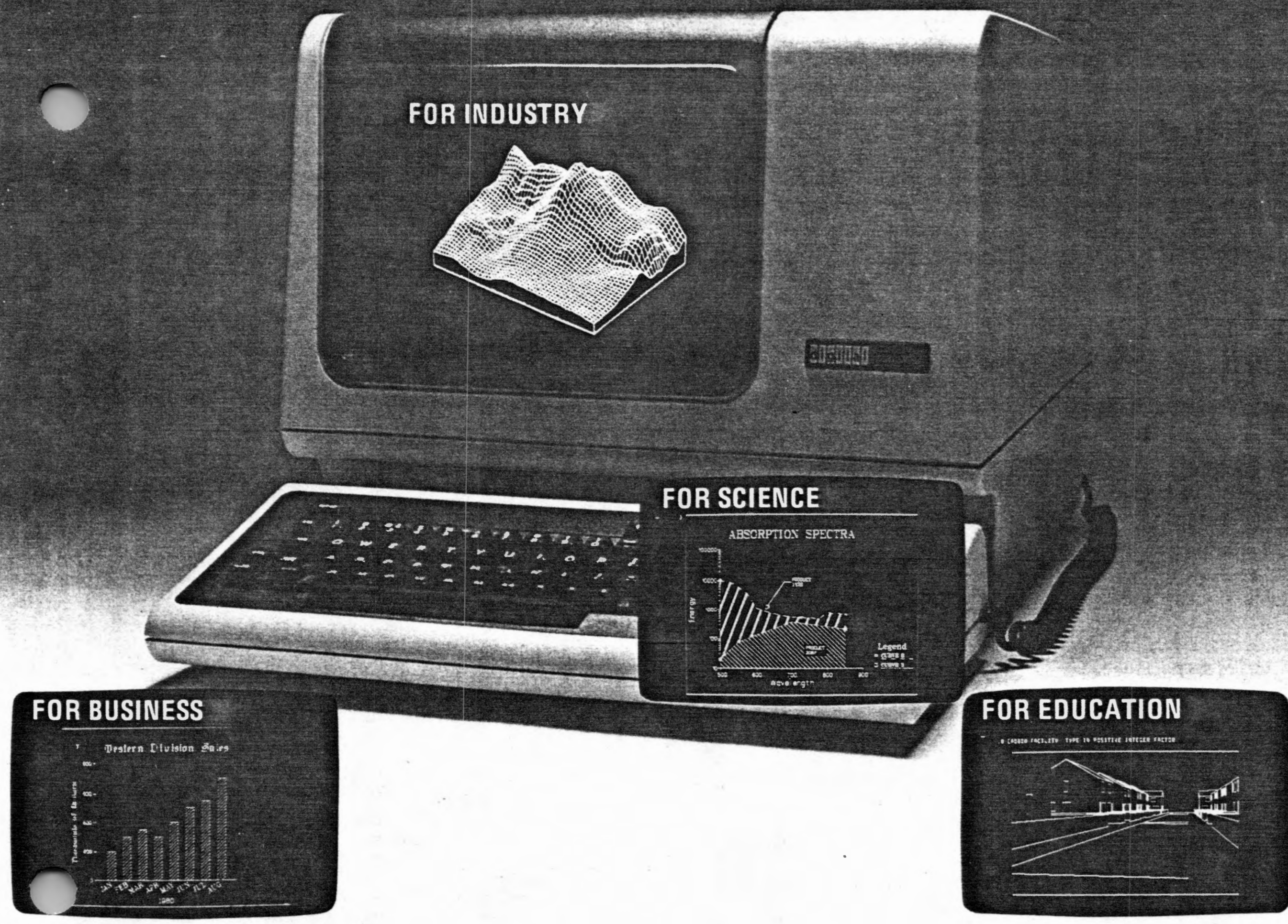
A comprehensive software package is provided for VG 33000 users, allowing the creation of specialized application programs without requiring detailed knowledge of internal hardware functions. The division of labor between the host computer and the display unit is determined by the package structure.

The basic VG 33000 configuration is priced at less than $50,000.

Reader Service Number 63



Vector General's VG 33000 interactive graphics system provides local processing to off-load the host computer.



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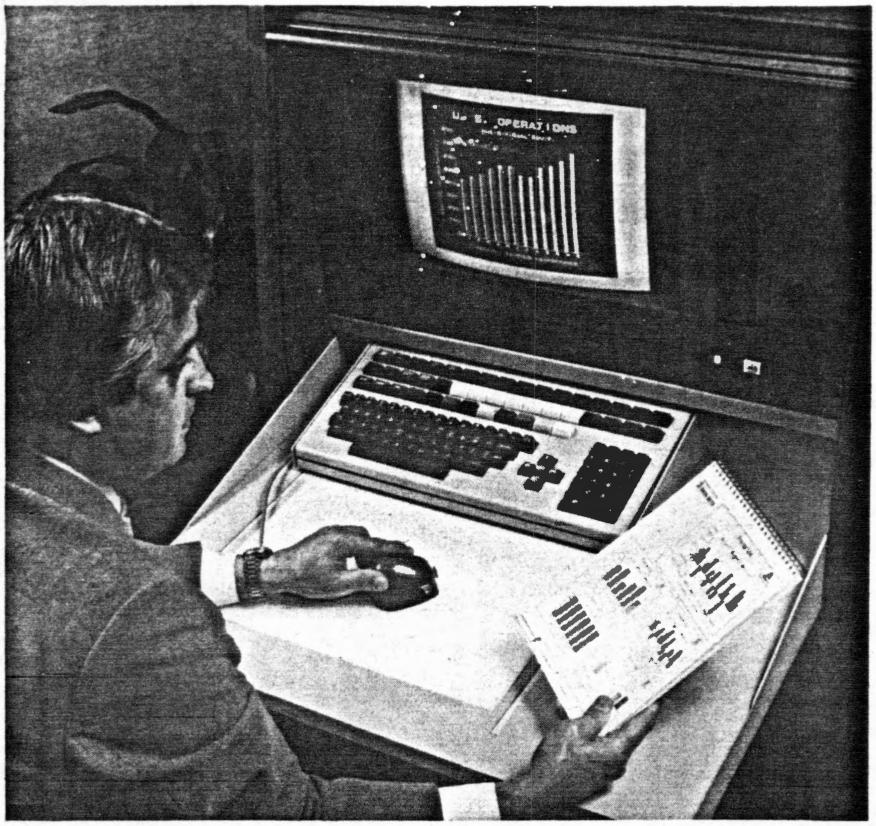


Designed for the business executive who has no knowledge of computer languages, programming, or operation, Comshare's Execuchart color graphics system creates visual displays of financial or other information with menu-driven or custom software and a mouse. Available in terminal, console, and custom units, Execuchart can create multiple progressive-disclosure slides and save 5000 charts or graphs.

Color business system uses pictorial cues

Comshare has introduced a color graphics system that requires of operators no knowledge of computer operation, language, or programming. According to figures compiled by the manufacturer, administrative and clerical personnel require an average training time of 2.1 hours. Execuchart, a family of three products to meet different volume requirements, produces color images, prints, and slides to depict numerical information graphically, helping managers detect, analyze, and revise trends, relationships, and "what if" factors affecting business.

The user-friendly system allows visual displays of financial or other information to be created by means of a mouse—a pointer-type, rapid-input device with three buttons to command action. The mouse slides over an electronic surface in front of a user. The system also uses pictorial cues, such as a paintbrush to signify color.

Graphs and charts can be designed on the screen of either a self-contained console unit or a tabletop terminal tied to the worldwide Comshare timesharing network. The terminal is designed for entry-level graphics users with moderate volume (up to 100 slides or prints a month). The console is aimed at volume users (more than 100 slides or prints a month). The third Execuchart family product is a database-oriented system for large-scale users requiring custom software and terminals at remote sites.

Peripherals include a color printer for chart prints on plain paper, a color camera for 35mm slides, and a plotter for color transparencies.

To operate the unit, the user responds to simple questions on the screen, selects the charting steps to be taken, then follows the series of questions asked on the screen and selects from a menu of answers. After the user picks the kind of data he wants, Execuchart organizes the data in the selected format, using proper scaling, axes, proportions, and colors.

For example, a typical first question is, "What do you want to do?" Possible answers listed on the menu are "create," "recall," and "modify." The user points the mouse at the desired answer and depresses a button. The process is repeated until a line, bar, pie, or other chart or graph is created. Input data may be the user's or may come from the timesharing network.

The terminal unit is priced at $14,000 or can be leased for $525 monthly plus maintenance. The console unit costs $45,000 or can be leased on a variable-range agreement, starting at $900 per month plus maintenance.

Reader Service Number 66

24-hour service turns computer-generated graphics into 35mm color slides

ISSCO has signed an agreement with SDI to provide a 35mm color-slide service for computer-generated graphics.

Designated ISSCOSLIDES, the service will guarantee 24-hour processing of Disspla and Tell-A-Graf graphic data files into color slides or film output. The service is available seven days a week to users of ISSCO computer graphics software.

According to ISSCO, the ISSCOSLIDES service is a significant improvement over the company's former slide-making program, providing faster turnaround, discount pricing, no required minimum number of slides, and monthly rather than project billing. Slide duplication and customized additions are also available.

The entire procedure is handled by mail. Users send a magnetic tape to the SDI processing center in Minneapolis, where the slides are produced on a Dicomed D48 color microfilm recorder, which provides a choice of eight basic colors with unlimited color mixing possibilities. Unless otherwise specified by the user, completed slides are returned via parcel post.

Fees for ISSCOSLIDES are $10 to $15 per slide, depending upon quantity.

Reader Service Number 67

System can display 256 colors selected from 16 million

Software-compatible with the manufacturer's RM-9000 series, Ramtek's RM-9450 graphics/imaging display system offers the most popular 9000-series features, including context-switching, display-list processing, high resolution fonts, clipping, textured lines, filled polygons, pan and zoom, high-speed erase, local functions, and a single cursor.

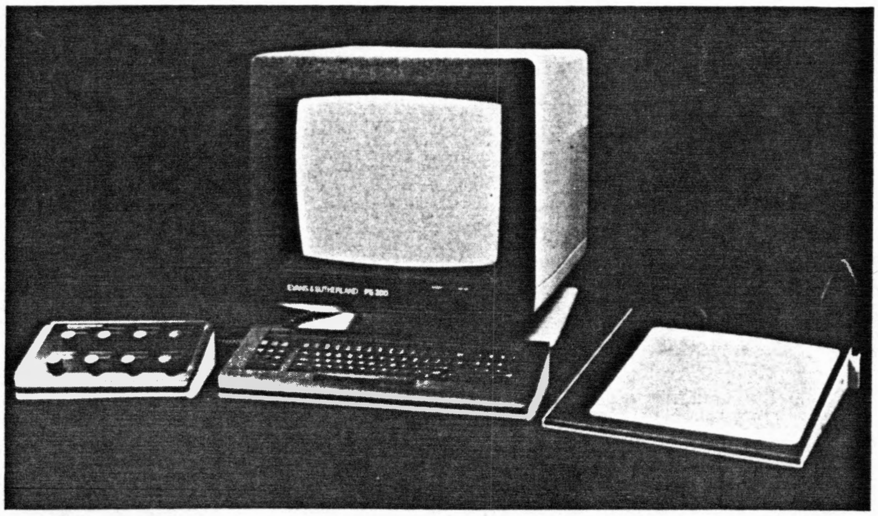
The RM-9450 is available with resolutions of 640 × 512 pixels at 25/30 or 50/60 Hz refresh rates, and 1280 × 1024 pixels at 25/30 Hz refresh rates. Memory configurations provide eight bits of refresh memory in the 640 × 512 versions, and four or eight bits of refresh memory in the higher resolution model. The system can display 256 colors simultaneously from a selection of 16 million.

For use in CAD/CAM, command and control, and process control—as well as in image processing applications such as seismic exploration, acoustic display, and pattern recognition—the RM-9450 is suitable for the single-user environment that does not require a large data base resident in the display generator.

The price of the RM-9450 ranges from $19,450 to $30,350, depending on selected resolution and interactive device options. Volume discounts are available.

Reader Service Number 68

System creates graphics without host participation



A self-contained, dynamic, interactive graphics system, the PS300 from Evans & Sutherland is the first of a new family of distributed graphics systems designed for CAD/CAM and other high-performance graphics applications.

Unlike traditional graphics terminals, the PS300 does not perform its graphics functions through the host computer; thus, E&S says, operating costs are reduced. The system operates wherever conventional communication lines are available, at any distance from the host computer, using standard RS-232 or RS-449 communication connections. It operates with a wide variety of host computers for application programs.

The PS300's calligraphic display system can compute and display images of up to 95,000 vectors per frame. Its operations include rotation, translation, scaling, clipping, and depth cueing to produce dynamic isometric or perspective drawings. The user can interactively manipulate objects by commands that allow the linking of devices and objects through a large library of functions. The system facilitates incremental building and changing of complex graphic data structures and permits object references by name.

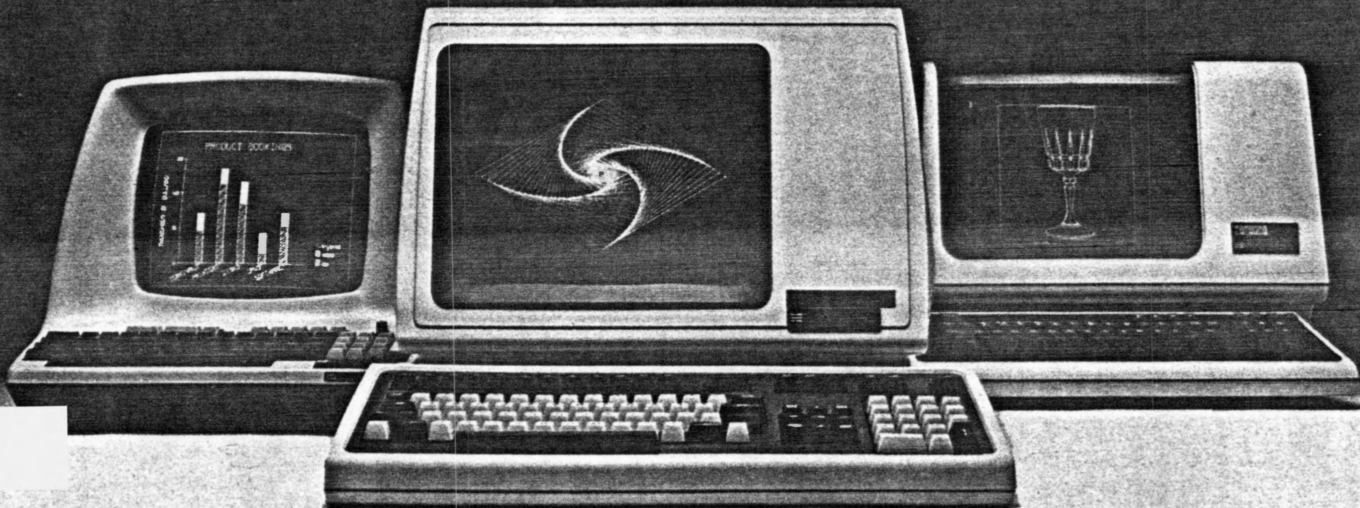
Maintenance facilities are built into the PS300. It can be serviced, and comprehensive diagnostic programs can be executed, without use of the host computer. When power is applied to the system, it automatically executes confidence tests.

The minimum PS300 includes 256K bytes of memory, which can be expanded to four megabytes. The system can be equipped with up to four monitors. Interactive devices available are an 11-inch tablet, eight control dials, and a freestanding alphanumeric keyboard with 12 function keys. A keyboard option provides alphanumeric LEDs, which can be programmed to provide an eight-character label for each function key. A similar LED option is available for the control dials.

The price of the PS300 starts at $69,500, with quantity and OEM discounts available.

Reader Service Number 69

Retro-Graphics,™ TI Style. Strong Gets Stronger.



It just makes sense. If you can successfully marry *two* strong ideas, the result will be *one* stronger idea. Example—Texas Instrument's recently introduced OPTI 900™ Model 940 Electronic Video Terminal. Clearly, the Model 940 fits the "strong idea" mold, combining the power of an editing terminal and the convenience of video display.

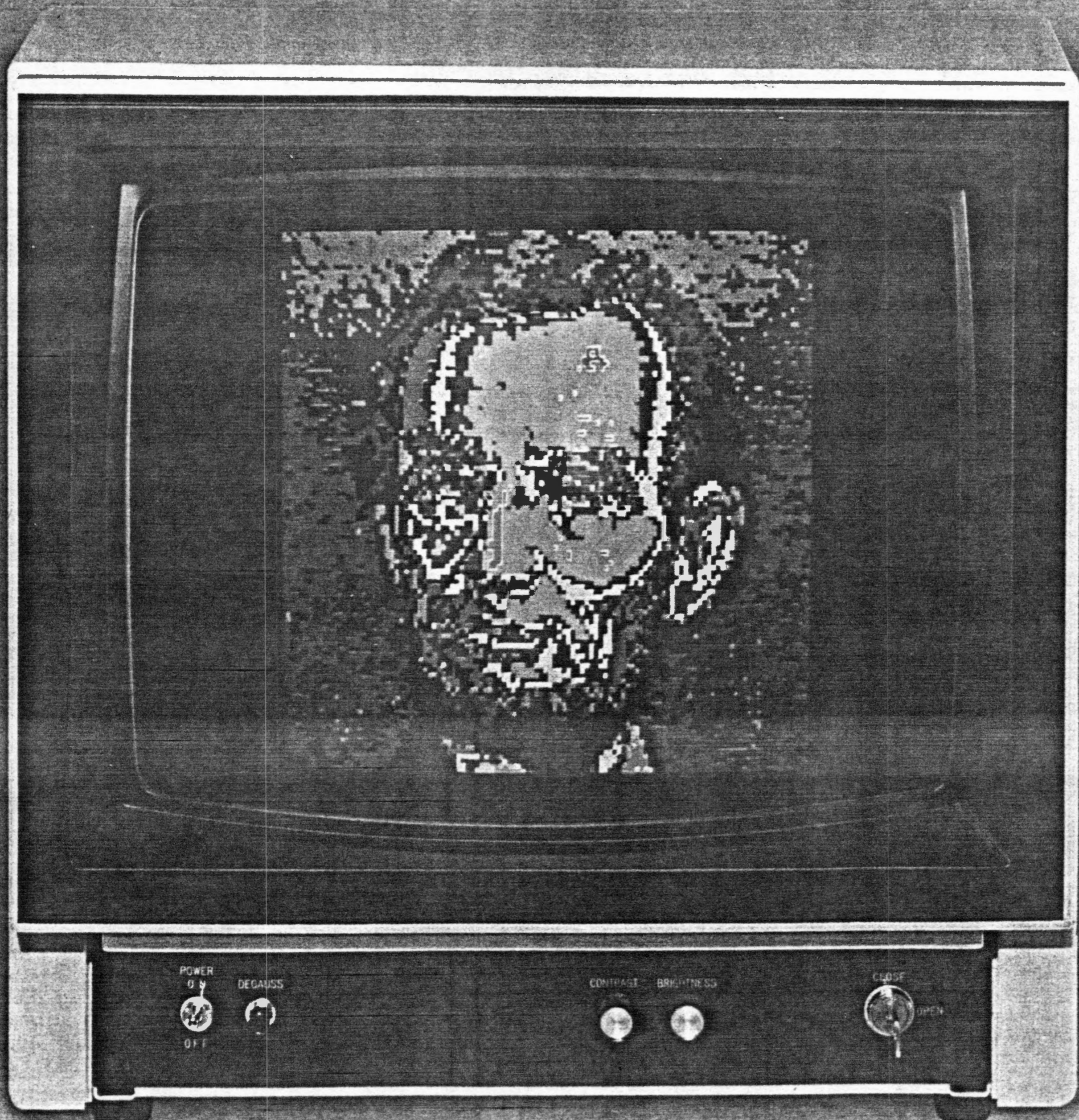
But what makes strong stronger is an idea of ours. The idea is the Retro-Graphics enhancement, an idea that adds one impressive feature to TI's Model 940—*graphics.* Full-featured graphics. With complete emulation of Tektronix® 4010 Series terminals. With two graphics bit planes for multiple intensity levels, or multiple pages of graphics display. With arc drawing, vector drawing, and point plotting capabilities. With area fill, selective erase, and an enhanced text mode. With an interactive cross hair cursor and an optional light pen. And, of course, complete compatibility with industry-standard graphics software, including ISSCO's® DISSPLA® and TELLAGRAF® and Tektronix PLOT 10.™

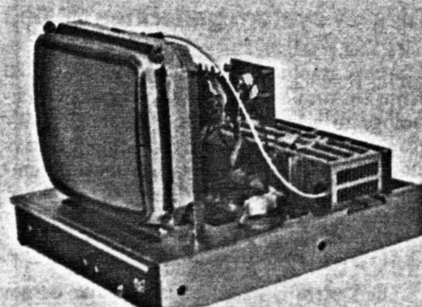
Strong gets stronger. It's a fact that Retro-Graphics has proven time and again. With Lear Siegler's Dumb Terminal® displays. With DEC's™ VT100™ terminal. And now, with the Model 940, TI's self-proclaimed "screen star," Retro-Graphics is making it shine just that much brighter.

DIGITAL ENGINEERING

630 Bercut Drive, Sacramento, CA 95814
(916) 447-7600 TWX: 910-367-2009

Reader Service Number 43


POWER
DEGAUSS
CONTRAST
BRIGHTNESS



Tab - “F-111 Display Data”

DEPARTMENT OF THE AIR FORCE
OL AK, 4444TH OPERATIONS SQUADRON (OTD) (TAC)
LUKE AIR FORCE BASE, AZ 85309

REPLY TO ATTN OF: THOMAS S. HILTON

SUBJECT: DISPLAY SPECIFICATIONS

TO: RAY Machmer
U.P R&D.

Dear Ray:

Please forgive this handwritten note, but this is the fastest way.

Page 21 gives the stroke sizes and page 31 Note 5 gives the smallest dot size. Pages 24 thru 29 give the character set.

We will be looking to here from you very soon.

Tom Hilton

Readiness is our Profession

~~3.3.17 Cockpit Equipment. - All rack or console mounted equipments shall conform to the applicable requirements of Specifications MIL-C-6781 and AV-1128CS-27. The configuration of all panels must be approved by the procuring activity prior to preproduction testing. Specification AV-1128CS-27 shall take precedence over subsidiary specifications of Specification MIL-C-6781.~~

~~3.4 Performance. - Unless otherwise specified, values set forth to establish the requirements for satisfactory performance apply to performance under both standard and extreme service conditions. When reduced performance under the extreme conditions is acceptable, tolerances or values setting forth acceptable variations from the performance under the standard conditions will be specified.~~

3.4.1 Operation. - The equipment shall accept input digital commands from a computer and, in conjunction with internal cursor, keyboard and panel controls, provide for multi-display mode presentations. Software programmable processing shall determine display presentation content.

3.4.1.1 Display Requirements. - The equipment shall be capable of providing the following display modes for the display.

3.4.1.1.1 Situation Display Mode (Figure 11). - This mode shall be composed of:

(a) Alphanumeric annotated scales of frequency in the vertical direction and azimuth in the horizontal direction. Scales and related annotation shall contain up to 75 alphanumerics.

(b) At least 6 rows of alphanumerics with up to 48 characters per row.

(c) A cursor symbol.

(d) A heading bug.

(e) Limited graphics.

SGN 1

3.4.1.1.1 (Continued)

(1) Up to 41 squares or rectangles; solid or dashed; steady or blinking.

(2) Up to four vertical solid/dashed lines - steady or blinking.

(3) Up to ten horizontal, solid/dashed lines - steady or blinking.

(f) Up to 512 emitter symbols. Normally emitter symbols shall be located within the emitter field.

3.4.1.1.2 Alphanumeric or Tableau Mode. - This mode shall contain characters in an array of 28 rows by 32 characters, 35 rows by 40 characters, 40 rows by 48 characters and 48 rows by 56 characters per row. This provides arrays of 896 to 2688 characters.

3.4.1.1.3 Spot Monitor Mode (Figure 18). - The equipment shall be capable of presenting a spectrum analysis type presentation on the display. Table II details the signal input and output requirements for this mode.

(a) The Spot Monitor Mode will be selected by an operator on an external panel. The annotation of the scale on the display shall depend on the Band Select input from the operator. For Bands 1, 2, 4, 5/6 and 7 the vertical sweep shall start at the lower left hand corner of the viewable area and sweep upward for 15 milliseconds ± 10%. During every sweep period a group of 255 Spot Monitor Clock pulses shall be sent by the DDG. This group will command the spectrum analysis receiver to tune through the selected band. Detected Video from the receiver shall be summed with the proper internally generated horizontal offset to place the Spot Monitor trace in the required location.

(b) A Sync/Reset pulse shall be provided. The Sync/Reset pulse trailing edge shall define the start of sweep. For Band 8 and 9 a double sweep shall be required as shown in Figure 18: Operation is simular to the single sweep except that the Sync/Reset pulse occurs on alternate sweeps. Thus the Sync/Reset trailing edge starts the sweep in the lower left corner and sweeps up for the first 15 milliseconds. During the alternate sweep period the sweep starts at the lower right center and again sweeps upward for 15 milliseconds.

3.4.1.1.3 (Continued)

(c) The period between sweeps in any band shall be 5.0 milliseconds ± 10%. A frame shall be a minimum of 20 milliseconds ± 10% for the lower bands and a minimum of 40 milliseconds ± 10% for bands 8 and 9. Annotation and scales shall be written during every period between sweeps.

(d) The Spot Monitor Mode shall provide for independent receiver (frequency) scan expansion for the operator. The cursor shall be positioned close to the scale (either scale for bands 8 and 9) at the frequency about which expansion shall occur. The EXP (expand) switch shall be depressed and the Special Software shall send a digital word to the external interface defining the Expand Start Frequency and its band. The Expand Start Frequency word transmission shall be initiated immediately following an EXPAND selection. Transmission shall be accomplished in the same manner as the Digital Display Data (DDD). Following the expand selection, the Special Software shall generate the Send Serial Data (SSD) interrupt to the external interface at the beginning of every Sync/Reset pulse. The Special Software shall also provide for an EXPAND discrete to the external interface for the operator. To return to the normal non-expanded mode, the operator shall depress the RTN (return) switch. Upon RTN activation, the Special Software shall send Expand Exit digital transmission to the external interface and drop the EXPAND discrete, and SSD interrupt.

(e) In the EXPAND mode only a single sweep is generated every frame for bands 8 and 9. The Sync/Reset pulse thus occurs every sweep cycle.

(f) When not in the Spot Monitor Mode all Spot Monitor outputs shall be inhibited.

(g) Provisons shall be made for a 5 times expansion of the Detected Video (horizontal deflection) presentation. A momentary Spot Monitor Expand pushbutton switch on the DDI shall enable this expansion as long as the switch is held depressed. All scales and other functions of the Spot Monitor Mode shall not be affected by this expansion.

3.4.1.1.4 Edit Mode. - In either the Situation Display Mode or the Tableau Mode the DDG shall be capable of off-line editing. A half line (row) shall be reserved at the bottom of the display for editing purposes only. At any time that a keyboard function switch is depressed, the selected character will be printed on the edit line (half line). One or more characters under software control may be placed into the edit line. The character or characters shall then be stored under display processing software control for subsequent transmission on the output interface. The edit line shall be capable of being cleared thru operation of the keyboard EDIT switch. Clearing of the edit line shall also be under display software control. The remaining half of the bottom line is under separate display software control.

3.4.1.2 Processing Requirements. - The DDG shall contain a general purpose digital computer. The Display Computer consisting of Input/Output (I/O), Central Processing Unit (CPU) and Memory shall be software programmable with 16K (16-bit) of core memory. All processing shall be performed within the Signal Data Computer-Converter. The SDC processing shall be capable of servicing the Digital Display Indicator controlled by the separate Digital Display Indicator Control. The total application software programming capability shall be categorized into two areas, Special Software and Display Software for display processing.

3.4.1.2.1 Special Software. - Special software capability shall be reserved for procuring activity use.

3.4.1.2.2 Display Software. - The Display Software shall be provided by the seller. It shall be used to meet the display processing requirements of this specification and shall, as a design goal use a maximum of 6.0K of core including refresh buffers. It shall provide for, but not be limited to, the following:

(a) Formatting programs for emitters, alphanumerics, vectors and symbols

(b) Serial input buffering

(c) Serial output buffering

(d) Keyboard routines

(e) Cursor control

3.4.1.2.2 (Continued)

(f) Interrupt servicing routines

(g) Display computer self-test

(h) DDG BIT

(i) Display refresh control

(j) Edit routine

3.4.1.2.3 Display Processing Time. - As a design goal the display processing shall be accomplished within 10.0 milliseconds of each 20.0 millisecond period. This shall include the process timing for display refresh cycle as well as that time to perform executive functions and generate I/O commands.

3.4.1.2.4 Display Refresh Buffer. - The Display Refresh Buffer for the display shall utilize up to a total of 4.0K (16 bit) words of memory. The Display Refresh Buffer shall be composed of the following separate buffers:

(a) Fixed Background for the Display - This buffer size shall be 0.4K (16 bits) words in length. The Fixed Background Buffer shall be divided into separate areas defined by software (each one shall represent a given fixed format). Each area shall be capable of being accessed individually by software during the refresh cycle.

(b) Dynamic Data Buffer - The display shall be provided with a Dynamic Data Buffer of up to 1.8K (16 bit) words defined by software.

The Dynamic Data Buffer shall be composed of the following segments:

(1) Edit Line

(2) Cursor Position

(3) Alphanumeric

(4) Emitter

(5) Heading Bug

Each of the above segments (1) thru (5) shall be capable of being accessed individually by software.

3.4.1.2.5 Display Processing. - See Appendix I

(a) The equipment shall have the capability to accept input digital commands in random order, singly or in blocks of words.

(b) The commands shall define a type of symbol, its display coordinate and other pertinent information. The specific commands (word definitions) and the processing to be performed for each command are shown in Table I.

(c) The equipment shall have the capability to store fixed display formats in the Fixed Background Buffer. Each format shall be composed of alphanumerics and scales (limited graphics).

(d) The equipment shall be able to merge a selected fixed display format from the Fixed Background Buffer with data from the Dynamic Buffer.

(e) The 16-bit internal control and Data Word Formats within the Display Software shall be as shown in Table III.

(f) One display shall be driven.

(g) Any alphanumeric character, symbol or graphic shall be capable of being positioned in any one of ±398 locations in the horizontal direction and in any one of ±512 locations in the vertical direction. Symbol Offset due to CRT beam settling after a major deflection shall be less than the equivalent of one (1) resolution location bit. Positive location is defined as to the right of center and above center. Thus there are 796 bits in the horizontal direction and 1024 bits in the vertical direction.

(h) Character and symbol size and spacing shall be under software control. Four sizes shall be provided by a control word preceding the character or symbol words in the refresh buffer. The four sizes shall be based upon having 32, 40, 48 or 56 characters per row. The 48 characters per row shall be regarded as the normal size. (See Figure 12, Note 5).

3.4.1.2.5 (Continued)

(i) All command switch functions on the DDIC including spares shall be made available to software.

(j) An input FIFO (first in-first out) memory providing storage for 32 words shall be provided. A FIFO full signal shall be or'ed with the halt signal to hold up input transmission when the FIFO is full. A FIFO not full signal shall only occur when at least one full 32-bit word slot is available in the FIFO.

(k) Within one word time (160 microseconds) after additional input data is requested (halt high) and no input data is received, the end of transmission for that block shall be presumed.

(l) A HALT signal (output from display) shall be low under the following conditions:

(1) During "gap" period between word transmissions (Table I and Figure 17).

(2) When input FIFO is full (see (j) above).

(3) When built-in-test SIC/SOC test is being performed.

3.4.1.2.6 Alphanumeric Characters. - The equipment shall be capable of generating the standard 64 character ASCII set except as noted in Figure 12. Software shall provide for the implementation of the 7-bit ASCII code. The Carriage Return control function shall be implemented. Carriage return is here defined as a return to the start "X" position and incrementing to the next row. The SP code shall be used to blank a character location (DO NOT PRINT). When characters are commanded in the typewriter mode to a location already occupied, the previous character shall be deleted by the software. Character fonts are shown in Figure 12.

3.4.1.2.7 Emitter Symbols. - Emitter symbol types shall be provided (see Figure 12). Up to 512 emitter symbols may be displayed in any mode, normal or expanded.

3.4.1.2.8 Limited Graphics. - The DDG shall provide for the generation of limited graphics which shall consist of rectangles and vectors. The elements of the rectangles shall be of various sizes but always horizontal or vertical. Input commands shall define two diagonal corners. Vectors shall be any length at any angle. Input commands shall define start and stop point. The DDG shall also provide for the generation of circles of different radii.

3.4.1.2.9 Other Symbols. -

(a) The DDG shall provide for the generation of a heading bug. See Figure 12. The heading bug shall always appear below the fixed heading scale.

(b) The DDG shall provide for the generation of four vertical lines, dashed or solid, steady or blinking.

(c) The DDG shall provide for up to ten horizontal lines, dashed or solid, steady or blinking.

3.4.1.2.10 Cursor Symbol and Control. - The cursor symbol shall be as shown in Figure 12 (sheet 6). Its position at all times shall be determined by the operator through the cursor control. The absolute cursor position coordinates shall be continuously available to the Display Software in all display modes.

In the Situation Display Mode the cursor shall address all possible emitter locations. Cursor position shall be capable of being transmitted to the external computer. The cursor symbol shall be expanded via the CUR EXP pushbutton switch; push to Expand, push to Normal. The expanded cursor symbol shall be a horizontal and a vertical line extending across the viewable area of the display.

The cursor shall be initially positioned in the upper left hand corner of the display upon turn on or mode change. The cursor symbol shall roll over from one edge to the opposite edge in both X and Y directions. The cursor symbol shall be software limited to the viewable area of the DDI at all times. The cursor symbol shall be moved at rates continuously variable from 5 bits per second to 500 bits per second. Cursor position interrupts into software shall occur no more than once approximately every refresh cycle, independent of the cursor slew rate.

3.4.1.2.11 DF Acceptance Sector. - When the DF SCTR switch is depressed, sector width information previously entered into the edit line thru keyboard operation shall be made available to Special Software. Special Software will rescale the display to present only the sector chosen.

3.4.1.2.12 Alarm Zone. - When the ALM ZONE switch is depressed, cursor position and keyboard data from the edit line shall be transmitted to the external computer. The external computer will in turn command two FREQ acceptance (horizontal) lines or two AZ acceptance (vertical) lines.

3.4.1.2.13 Keyboard Operation. - Whenever the first alphanumeric keyboard switch is depressed the character is placed in the edit line at the location defined by the X-Y code in the initial alphanumeric word. Successive key operation shall automatically index the next alphanumeric entered to the next location in the X-axis.

3.4.1.2.14 Display Commands. - The Display Commands are operator actuated momentary action switches. In either operation the Display software shall retain the last command of each switch and provide these commands as bits in an output Status Discrete word. This word shall be transmitted to the external computer each time a Display Status request (discrete) is received from the external computer.

3.4.1.2.15 Deleted

3.4.1.2.16 Transient Protection. - Transients or other variations in Primary Input Power having NORMAL limits as specified in MIL-STD-704 shall not cause any loss of data. In addition NORMAL operation shall not be interrupted and no automatic power-down shall be allowed. Transients or other variations in Primary Input Power up to the ABNORMAL limits specified in MIL-STD-704 shall not cause any loss of core memory data. In addition, no loss of core memory data shall occur due to normal equipment turn on or normal equipment turn-off. The overvoltage detection protect circuitry shall be set to power-down the SDC for ac line voltage in excess of 160 Vac but shall be insensitive to line transients of less than 50 usec. duration. Provision shall be made for the automatic reset of the DDI when the SDC has powered-down and automatically powered-up in response to a power line transient.

3.4.1.2.17 Display Response Time. - The display presentation shall respond to any input command or internal command within two refresh cycles.

3.4.1.3.9.2 Relative Positional Accuracy. - Symbols commanded to coordinates within 0.25 inches of each other shall deviate by no more than 0.030 inches from the true relative reference position of each symbol.

3.4.1.3.10 Display Refresh. - The display refresh rate shall be a minimum of 50 Hz. When writing time exceeds the 50 Hz refresh period, the period shall be controlled by the length of time required to display one complete frame. When displaying the Situation Display as defined in 3.4.1.1.1, the writing time shall be less than 25 milliseconds.

3.4.1.3.11 CRT. - The viewable area of the CRT shall have minimum dimensions of 9.0 inches vertically by 7.0 inches horizontally. The CRT shall conform to MIL-E-1.

3.4.1.3.12 Phosphor. - The phosphor used shall be P-43 and shall meet the applicable requirements of MIL-E-1.

3.4.1.3.13 Deleted.

3.4.1.3.14 Phosphor Protection. - A phosphor protection system shall be incorporated into the equipment for the purpose of prevention of any damage to the CRT phosphor as a result of loss of sweep voltages, turn on or turn-off transients or excessive CRT beam drive. The protection system should prohibit any abnormal phosphor deterioration other than normal phosphor life deterioration as defined in MIL-E-1.

3.4.1.3.15 Noise. - Noise or extraneous video appearing on the CRT due to internal processing directly or indirectly, shall be less than 10 percent of the brightness of the desired information. This shall apply at all brightness (contrast) settings.

3.4.1.3.16 Day Filter. - A day light filter shall be provided as an integral part of the equipment. There shall be no loss in resolution when viewing the CRT at a distance of 28 inches within a cone of 60 degrees.

SPECIFICATION

No. AV-273B-CS-14F SCN 1

TABLE I - DIGITAL DISPLAY GROUP DATA TRANSMISSION INTERFACE

Input & Output:	Differential; input defined at input terminals; output defined at load terminals. Lo = 0.0 to 0.4 volts Hi = 2.4 to 6.0 volts
Load:	Fairchild 9615 or equivalent with 510 ohm ±10% terminating line to line at end of 50 feet of twisted shielded pair (GAC GC-18k or equivalent) size #22.
Source:	Fairchild 9614 or equivalent
Pulse Width (P_W)	Defined at 50% points
Rise Time (t_r)	Defined at leading edge from 10% to 90% points
Fall Time (t_f)	Defined at trailing edge from 10% to 90% points
Output Data:	Type NRZ $t_r = t_f = < 0.5$ us pw = 5us (nominal)
Input Data:	Type NRZ $t_r = t_f = < 0.75$ us Pw = 5us (nominal)
Input Clock:	Frequency: 200kHZ ± 0.1%; delayed 1.25 ± 0.20us from the serial data. Duty Cycle: 45 to 55% Pw: 2.5 us (nominal) $t_r = t_f = < 0.75$ us
Output Clock:	Same as above except coincident with data ± 0.2 us $t_r = t_f = < 0.50$ us

Discrete (input to display)

P_w = 10 us (min); 15 us (max)

$t_r = t_f = <1.0$ us

Interrupt (output from display)

P_w = 10 us (min); 15 us (max)

$t_r = t_f = <1.0$ us

Halt (Output from display)

$t_r = t_f = <1.0$ us

Discrete level defining gap and word length. Goes to logic "0" after the 16th data pulse is received. Goes to logic "1" at the end of the 15 us word gap following each word.

TABLE II - SPOT MONITOR INTERFACE

INPUT TO DIGITAL DISPLAY

A. DETECTED VIDEO

Single-ended Analog, dc coupled

1.0 volts (Full Scale)
2.0 volts (Max.)
Load impedance: 1.5k ohms
Cable: Coax, RG-180

B. SPOT MONITOR MODE SELECT

T^2L load with 1k pull-up resistor
Open = mode not selected
Ground = mode selected

C. BAND SELECT

7 lines (one for each band)
Each a T^2L load with 1k pull-up resistor
Open = Band not selected
Ground = Band selected

OUTPUT FROM DIGITAL DISPLAY

A. SYNC/RESET

Digital differential, 0 volts and 5 volts
Driver: Fairchild 9614 (or equivalent) to drive Fairchild 9615 (or equivalent) with 510 ohm line/line terminating resistor at end of 20 ft. of GAC GC-18K twisted shielded pair.

Lo = 0.0 to 0.4V
Hi = 2.4 to 6.0V
Pulse Width (Pw) = 5.0 milliseconds

$t_r = t_f < 0.1$ millisecond

Period = 20 miliiseconds ± 10% for Band 1,2,4,5/6 and 7 and all Expanded Bands.

Period = 40 milliseconds ± 10% for Bands 8 and 9 (normal)

TABLE II - SPOT MONITOR INTERFACE (Continued)

OUTPUT FROM DIGITAL DISPLAY (Continued)

B. SPOT MONITOR CLOCK

Digital differential, 0 volts and 5 volts
Driver: as above
Levels: as above

255 pulses during every active vertical display sweep

Duty cycle: 45% to 55%

$t_r = t_f < 1.5$ us

C. EXPAND

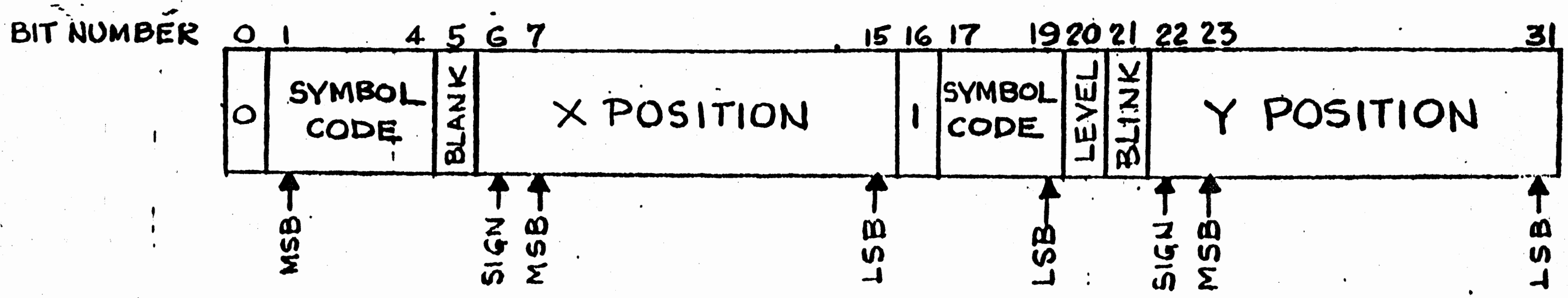
To drive standard T^2L load
High Level (active) = NORMAL
Low Level = EXPAND

NOTE: The expand output shall be DOP 7. (one of the six DOP's as defined in Table IV).

TABLE III - INTERNAL CONTROL & DATA WORD FORMATS (SEE NOTES)

ALPHANUMERIC (a/n) FORMAT

FIRST WORD



BIT 0 (CONTROL BIT): 0 = 1ST ALPHANUMERIC IN TYPEWRITER MODE

BITS 1, 2, 3, 4, 17, 18 & 19: 7 BIT CHARACTER CODE ** FOR a/n

BIT 20: 0 = LOW LEVEL, ALL CHARACTERS IN STRING
1 = HIGH LEVEL, " " " "

BIT 5: 0 = NORMAL (DO NOT BLANK CHARACTERS)
1 = BLANK ALL CHARACTERS IN STRING

BIT 16: 1 = START OF SECOND 16-BIT GROUP

BIT 21: 0 = NORMAL
1 = BLINK ALL CHARACTERS IN STRING

** SEE FIGURE 12 FOR CODE

SHEET 1 OF 9

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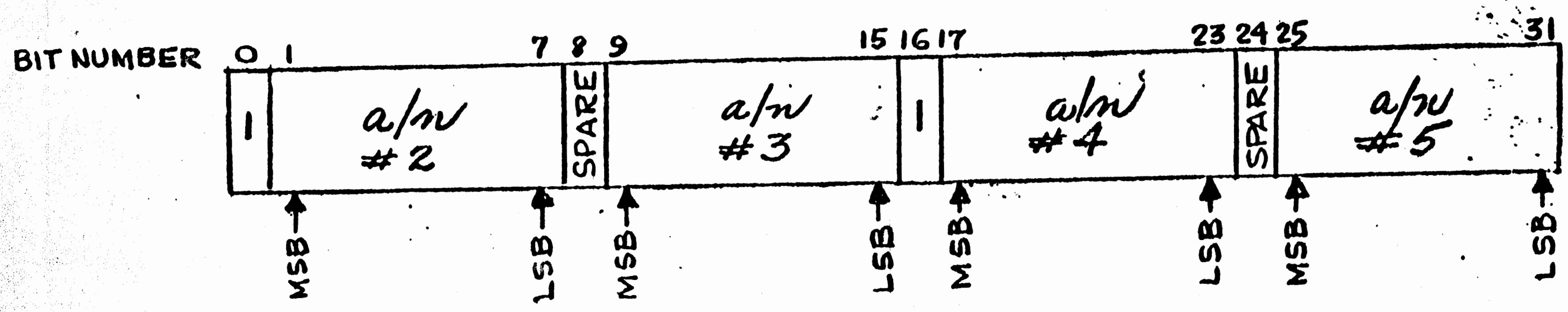
TABLE III - INTERNAL CONTROL & DATA WORD FORMATS (CONT.)

ALPHANUMERIC (a/n) FORMAT (CONT.)

CONTINUATION WORD

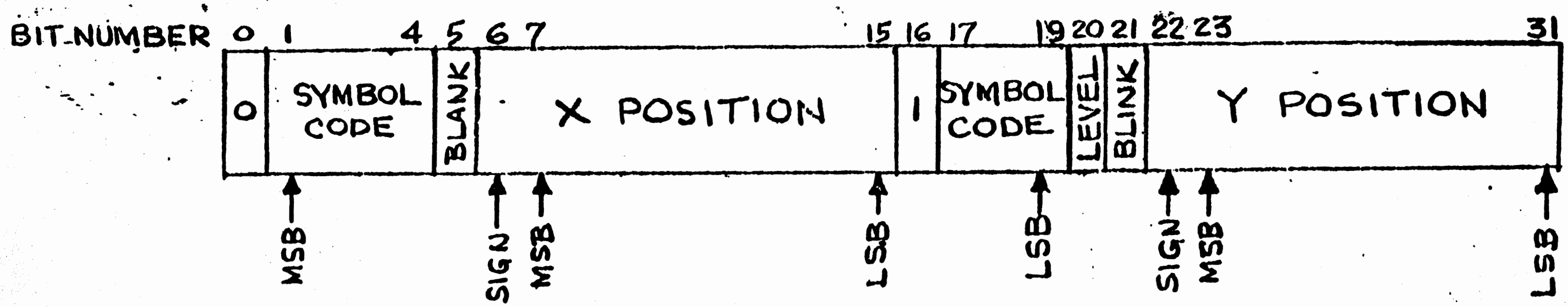


BIT 0 (CONTROL BIT)	1 =	CONTINUATION WORD DEFINING NEXT GROUP OF ALPHANUMERIC CHARACTERS IN STRING
BIT 1-7, 9-15, 17-23, 25-31	=	a/n CHARACTER CODES
BIT 16	1 =	START OF SECOND 16-BIT GROUP
BIT 8 & 24	=	DON'T CARE

TABLE III - INTERNAL CONTROL & DATA WORD FORMATS (CONT.)

SYMBOL FORMAT

(EMITTER, CURSOR, HEADING BUG OR OTHER SYMBOL)



BIT 0 (CONTROL BIT)	0 = NEW WORD
BITS 1, 2, 3, 4, 17, 18 & 19	7 BIT CHARACTER CODE** FOR SYMBOLS
BIT 20:	0 = LOW LEVEL 1 = HIGH LEVEL
BIT 5:	0 = NORMAL (DO NOT BLANK SYMBOL) 1 = BLANK SYMBOL
BIT 16:	1 = START OF SECOND 16-BIT GROUP
BIT 21:	0 = NORMAL 1 = BLINK SYMBOL

** SEE FIGURE 12 FOR CODE

SHEET 3

16

TABLE III - INTERNAL CONTROL & DATA WORD FORMATS (CONT.)

VECTOR/RECTANGLE FORMAT

FIRST WORD

BIT NUMBER	0	1–4	5	6–15	16	17–19	20	21	22–31
	0	SYMBOL CODE	BLANK	X POSITION	1	SYMBOL CODE	LEVEL	BLINK	Y POSITION
		MSB (bit 1)		SIGN (bit 6), MSB (bit 7), LSB (bit 15)		LSB (bit 19)			SIGN (bit 22), MSB (bit 23), LSB (bit 31)

BIT 0 (CONTROL BIT) — 0 = INITIAL POSITION OF VECTOR/RECTANGLE

BIT 1,2,3,4,17,18 & 19 — 7 BIT CHARACTER CODE** FOR VECTOR/RECTANGLES, DASHED OR SOLID

BIT 20:
- 0 = LOW LEVEL
- 1 = HIGH LEVEL

BIT 5:
- 0 = NORMAL (DO NOT BLANK)
- 1 = BLANK VECTOR OR RECTANGLE

BIT 16:
- 1 = START OF SECOND 16-BIT GROUP

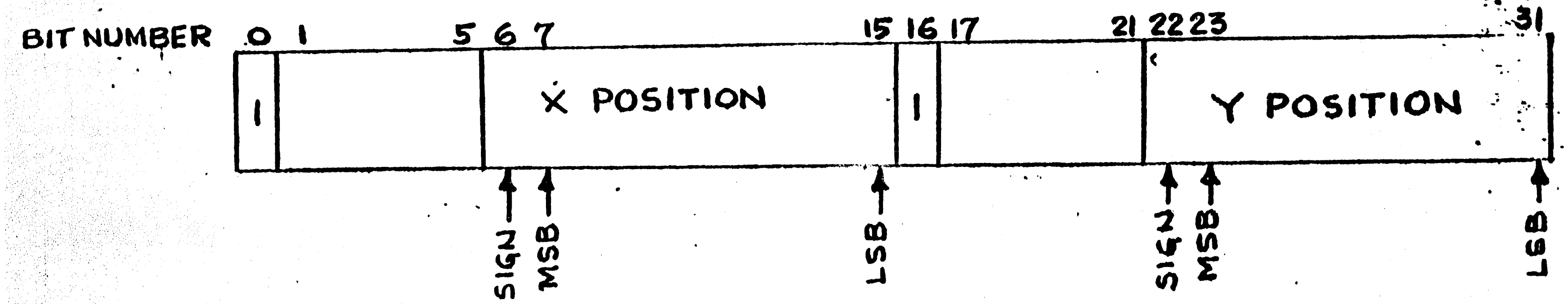
BIT 21:
- 0 = NORMAL
- 1 = BLINK VECTOR OR RECTANGLE

** SEE FIGURE 12 FOR CODE

TABLE III - INTERNAL CONTROL & DATA WORD FORMATS (CONT.)

VECTOR/RECTANGLE FORMAT (CONT)

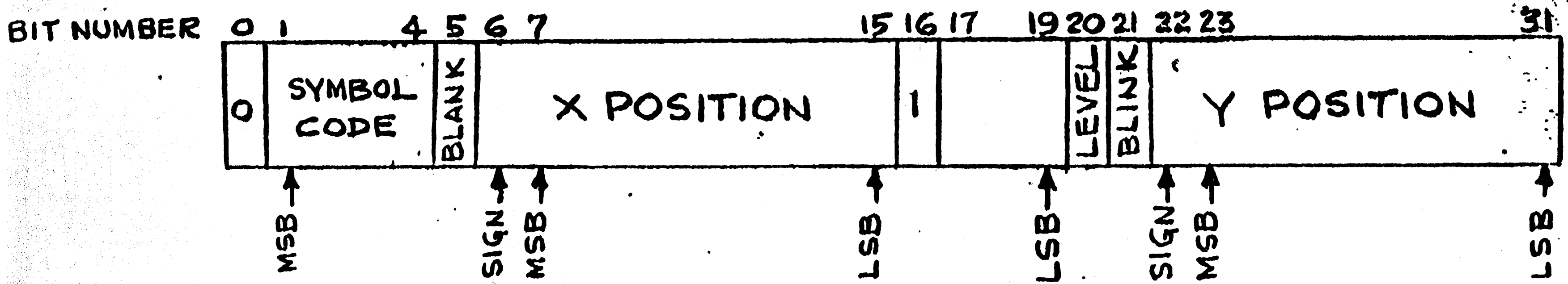
CONTINUATION WORD



BIT 0:	1 =	CONTINUATION WORD DEFINES FINAL POSITION OF VECTOR; OR DIAGONAL POSITION OF RECTANGLE
BIT 16:	1 =	START OF SECOND 16-BIT GROUP
BIT 1-5, 17-21:	=	DON'T CARE

TABLE III - INTERNAL CONTROL & DATA WORD FORMATS (CONT.)

CIRCLE FORMAT



BIT 0 (CONTROL BIT):	0 =	NEW COMMAND
BITS 1,2,3,4,17,18 & 19:		7 BIT CHARACTER CODE** FOR CIRCLE
BIT 20:	0 =	LOW LEVEL
	1 =	HIGH LEVEL
BIT 5:	0 =	NORMAL (DO NOT BLANK)
	1 =	BLANK CIRCLE
BIT 16:	1 =	START OF SECOND 16-BIT GROUP
BIT 21:	0 =	NORMAL
	1 =	BLINK CIRCLE

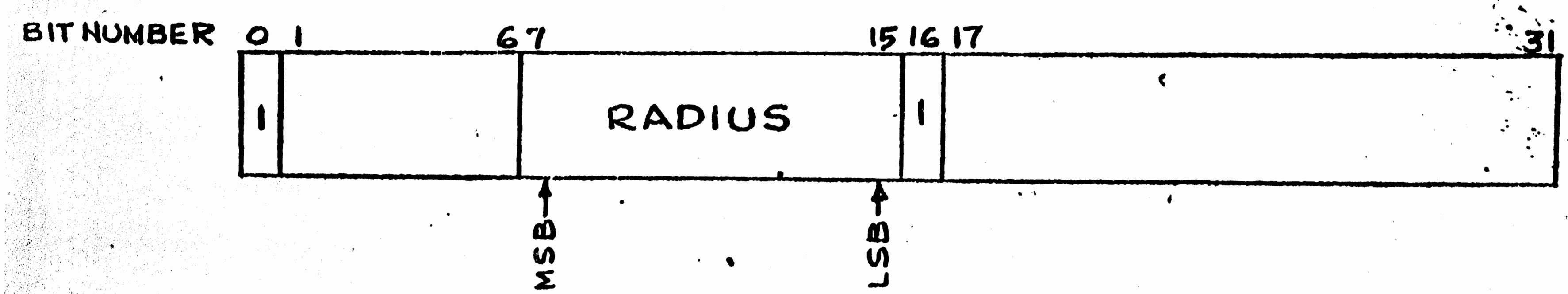
** SEE FIGURE 12 FOR CODE

SHEET G

TABLE III - INTERNAL CONTROL & DATA WORD FORMATS (CONT.)

CIRCLE FORMAT (CONT.)

CONTINUATION WORD



BIT 0 :	1 =	CONTINUATION WORD DEFINING RADIUS OF CIRCLE
BIT 16 :	1 =	START OF SECOND 16-BIT GROUP
BIT 1-6, 17-31		DON'T CARE

SHEET 7

SCN 1

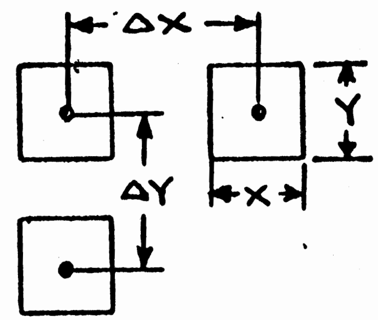
TABLE III - INTERNAL CONTRO[illegible] DATA WORD FORMATS (CONT.)

SYMBOL SIZE CO[illegible]OL WORD FORMAT

BIT NUMBER	0	1–4	5	6–7	8–15	16	17–19	20–23	24–31
	0	SYMBOL CODE		SIZE CODE	SPACING ΔX	1	SYMBOL CODE	DON'T CARE	SPACING ΔY
		MSB at bit 1			MSB at bit 8, LSB at bit 15		LSB at bit 19		MSB at bit 24, LSB at bit 31

SIZE CODE		CHAR/LINE	ASCII NOMINAL SPACING		ALPHA SIZE INCHES		STROKE SIZE (INCH)
BIT 6	BIT 7		ΔX BITS	ΔY BITS	X	Y	
0	0	56	14	21	0.0901	0.1352	0.02253
0	1	48	16	24	0.1055	0.1582	0.02637
1	0	40	20	29	0.1262	0.1894	0.03165
1	1	32	24	36	0.1582	0.2373	0.03954

42 ROWS → (first row)
NORMAL



BIT 0: CONTROL BIT

BIT 1-4, 17-19: 7-BIT CHARACTER CODE** FOR SYMBOL SIZE CONTROL WORD

BIT 6, 7: SIZE CODE

BIT 16: 1 = START OF SECOND 16 BIT GROUP

BIT 5, 20-23: DON'T CARE

NOTES: (1) 1 BIT = 0.00879 INCH

(2) SYMBOLS OTHER THAN ASCII CHARACTERS REQUIRE SPECIAL ΔX, ΔY SPACING

(3) THE CONTROL WORD MUST BE ENTERED AS THE FIRST WORD IN THE REFRESH MEMORY AND BEFORE EACH CHANGE OF SYMBOL SIZE

** SEE FIGURE 12 FOR CODE

TABLE III - INTERNAL CONTROL & DATA WORD FORMATS (CONT.)

~ NOTES ~

- ALL WORDS ARE 32 BITS. (TWO GROUPS OF 16 BITS EACH).
- WHEN TRANSMITTED SERIALLY, ALL WORDS ARE TRANSMITTED WITH THE "0" BIT FIRST. (MSB FIRST)
- BIT "0" IN ALL WORDS SIGNIFIES THE FOLLOWING:

  BIT 0 = 0 INDICATES START OF NEW COMMAND (WORD).
  BIT 0 = 1 INDICATES CONTINUATION OF COMMAND (WORD).

- UNLESS SPECIFIED OTHERWISE IN THIS TABLE OR FIGURE 12, THE GEOMETRIC CENTER OF THE SYMBOL OR FONT SHALL BE DEFINED AS LOCATED AT THE COMMANDED X, Y POSITION.

TABLE IV - POWER AND CONTROL INTERFACE

A. Power and Control Inputs to the DDG

1 - 115 VAC, 1 Ø, 400 Hz

2 - 28 VDC Lighting (Annunciator) (14 V. Dim)

3 - 5 VAC Lighting (Variable)

4 - Lamp Test — Open = No test
Ground = Test

5 - External Bit — Open = No external BIT
Ground = External BIT, Pull up resistor of 300 ohms to 5V externally connected

6 - Display Reset (RSD) - Differential discrete (See Table I for Characteristics)

B. Control Outputs provided by the DDG

1 - Display ON (DOI) - T^2L — High = Display ON
Low = Display OFF, Unpowered, Standby or Reset

2 - GPC Discretes (DOP) - T^2L — High = Logic 1
Low = Logic 0

3 - Recorder Outputs (available on Test Connector)

(a) Video: Analog differential, 0 to 2.0V; 0 = blank, 2.0V = peak video. Load = 91 ohms (line to line)
One output line held at 0 signal level.

(b) Vsc (Vertical Deflection): Analog differential, ±2.0V. Positive = deflection above center. One output line held at zero signal level. Load = 91 ohms (line to line)

(c) Hsc (Horizontal Deflection): Analog differential, ±2.0V. Positive = deflection to right. One output line held at zero signal level. Load = 91 ohms (line to line)

CRT CHARACTER FORMAT (See Note 1)

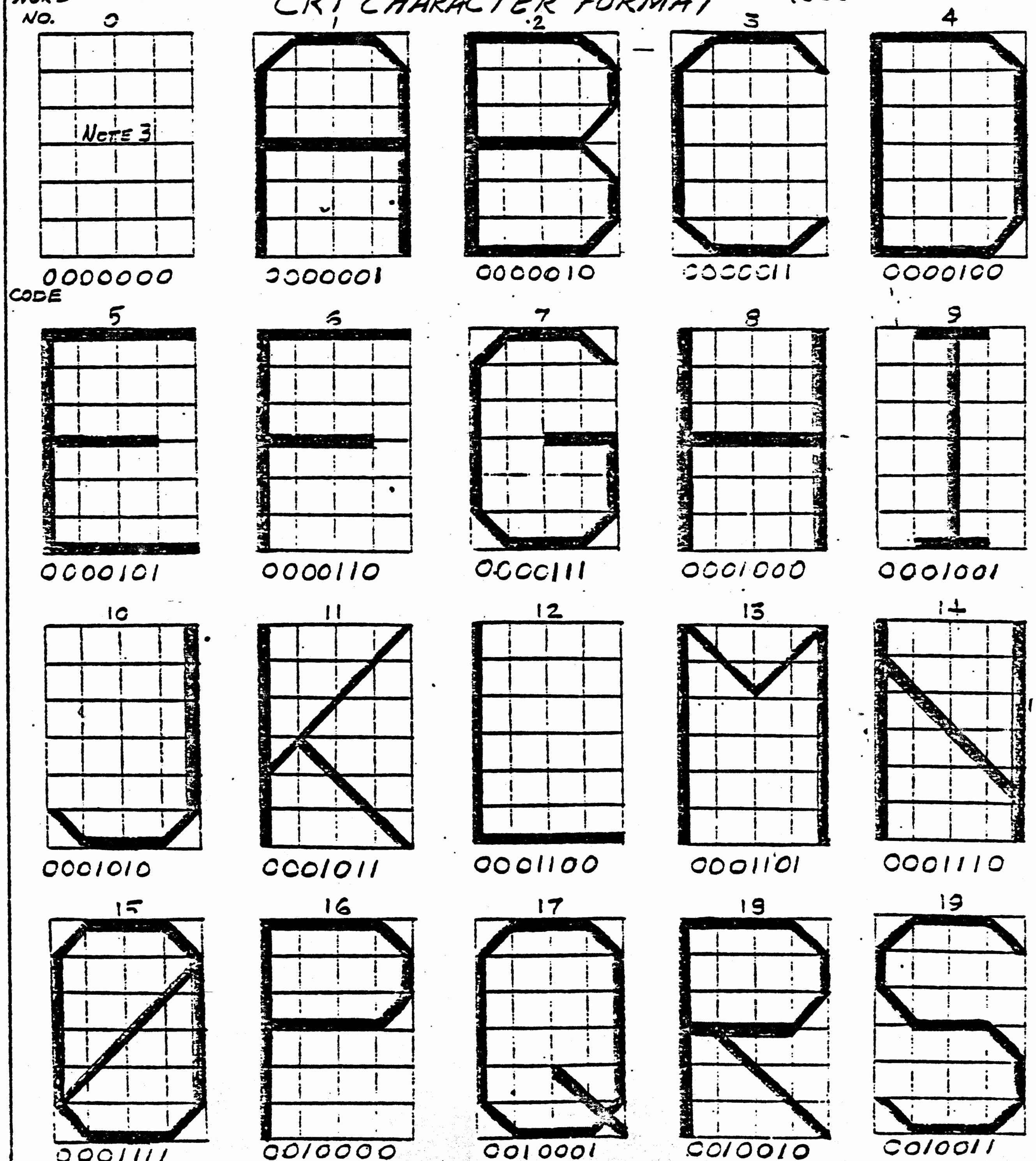


FIGURE 12 SHEET 1 OF 8

SPECIFICATION

No. AV-273B-CS-14F

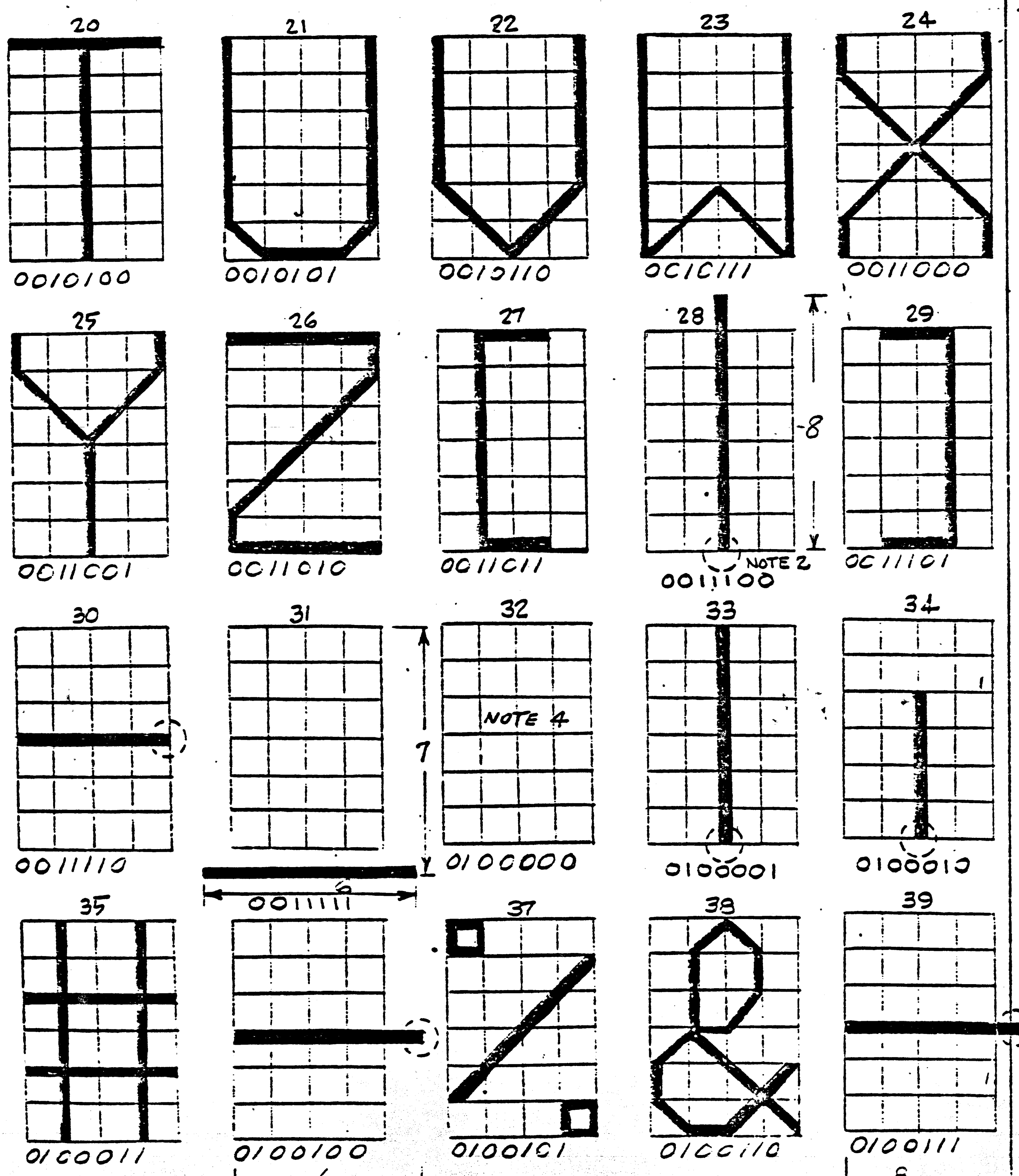


FIGURE 13 SHEET 2

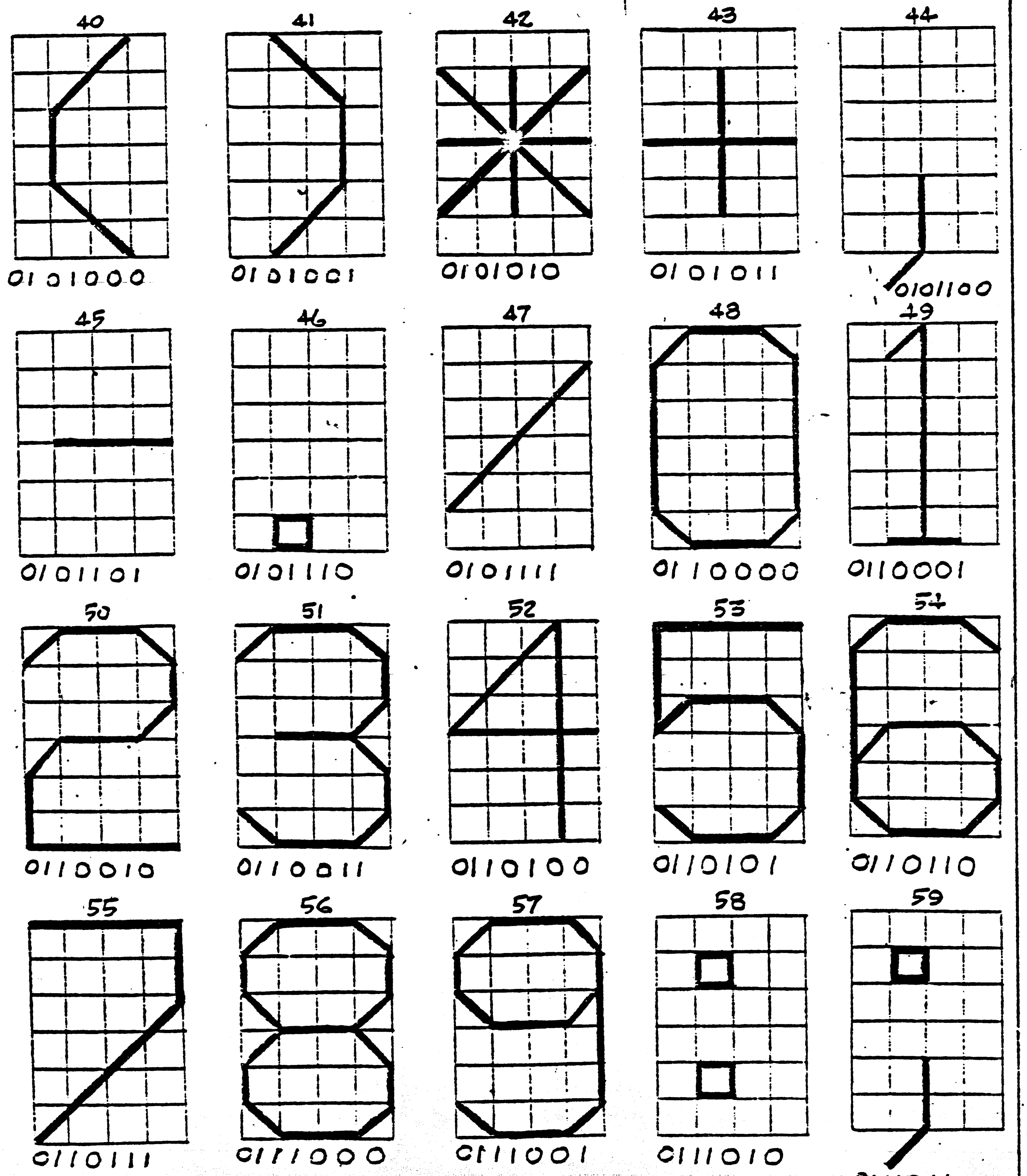


FIGURE 12 SHEET 3

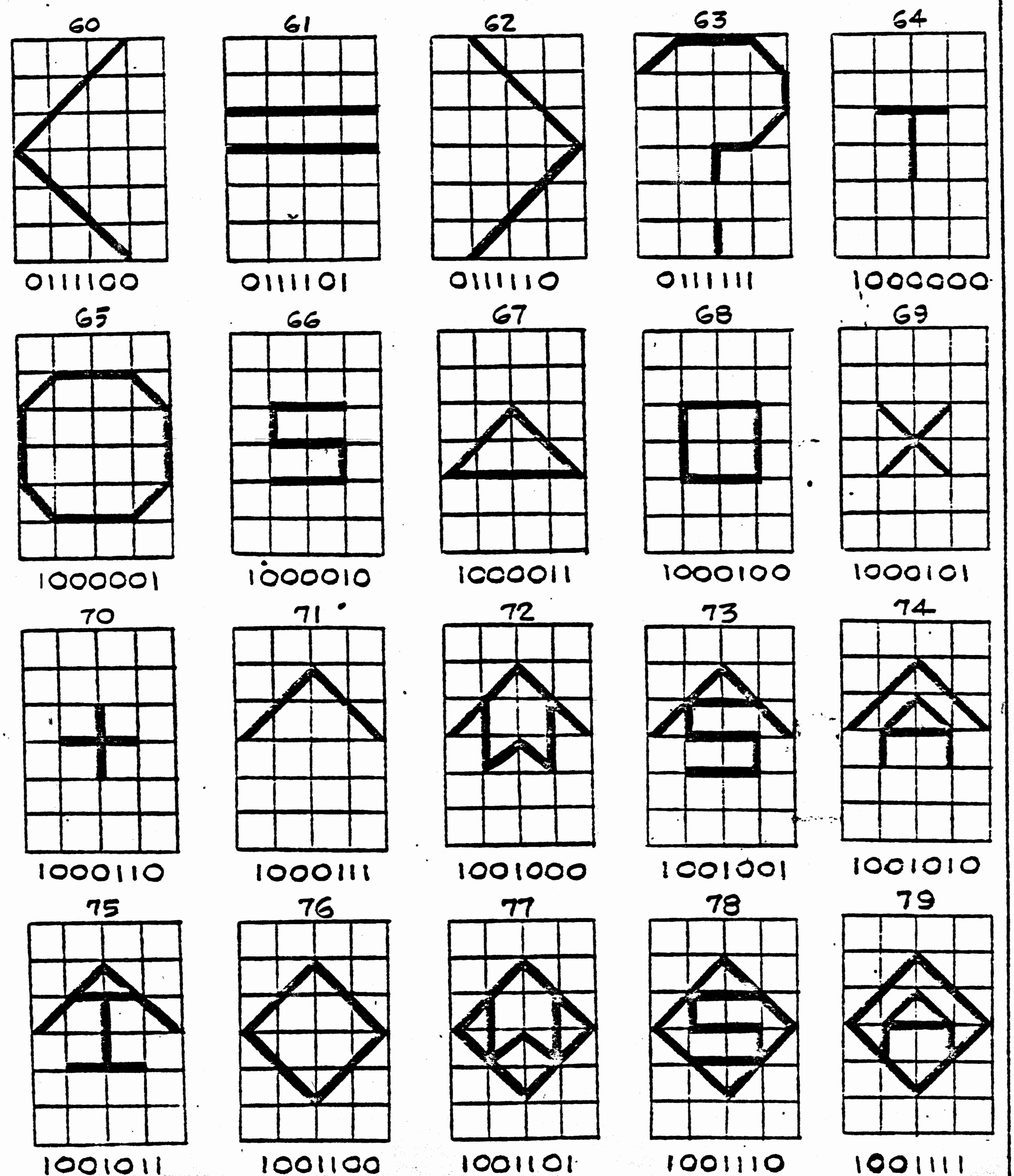


FIGURE 12 SHEET 1

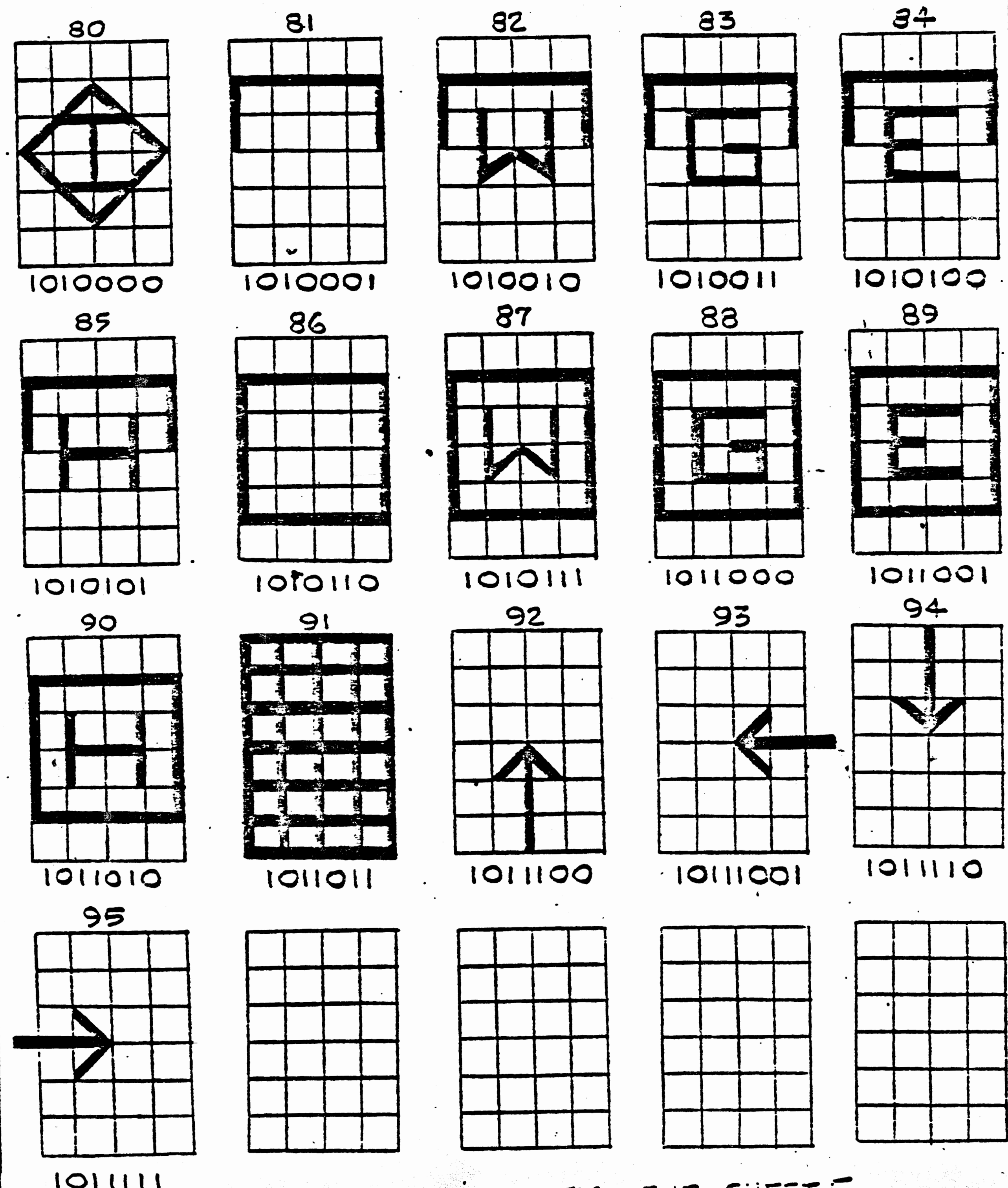


FIGURE 12 SHEET 5

SPECIFICATION

No. AV-273B-CS-14F

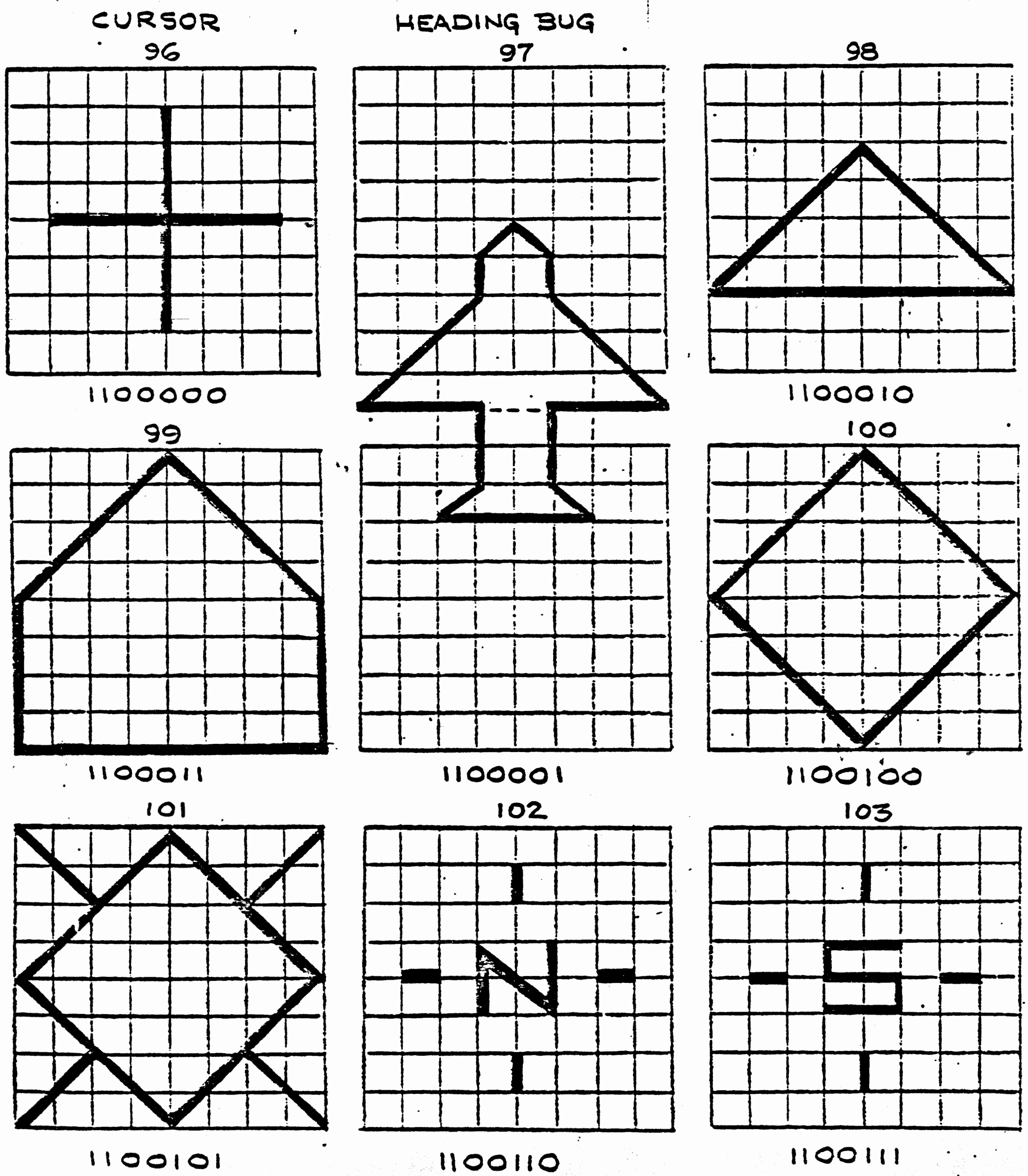


FIGURE 12 SHEET 6

WORD NUMBER	7 BIT CODE 7 6 5 4 3 2 1 MSB LSB	SYMBOL	NOMENCLATURE DESCRIPTION
104	1 1 0 1 0 0 0		Not used
105	1 1 0 1 0 0 1		Not used
106	1 1 0 1 0 1 0	o	Variable Radius Circle
107	1 1 0 1 0 1 1		
108	1 1 0 1 1 0 0		
109	1 1 0 1 1 0 1		
110	1 1 0 1 1 1 0		Not used
111	1 1 0 1 1 1 1		
112	1 1 1 0 0 0 0		Solid Rectangle
113	1 1 1 0 0 0 1		Solid Vector
114	1 1 1 0 0 1 0		Dashed Rectangle
115	1 1 1 0 0 1 1		Dashed Vector
116	1 1 1 0 1 0 0		
117	1 1 1 0 1 0 1		
118	1 1 1 0 1 1 0		Not used
119	1 1 1 0 1 1 1		
120	1 1 1 1 0 0 0	Control	Carriage Return + Forward L.F.
121	1 1 1 1 0 0 1	Control	
122	1 1 1 1 0 1 0	Control	
123	1 1 1 1 0 1 1	Control	Not used
124	1 1 1 1 1 0 0	Outside Symbol	
125	1 1 1 1 1 0 1	Control Symbol size	
126	1 1 1 1 1 1 0	Bite Test Symbol	
127	1 1 1 1 1 1 1	Outside Symbol Delayed	

FIGURE 12 Sheet 7

CRT CHARACTER FORMAT

NOTE 1. Reference Position: Unless otherwise noted, reference position is geometric center of matrix shown.

NOTE 2. Indicates reference position of these symbols only. Not part of symbol

NOTE 3. Code 0000000 used for IGNORE

NOTE 4. Code 0100000 used for BLANK

NOTE 5. For the normal size characters or symbols each elemental stroke shall be 3 bits long. Each bit shall be 0.00879 inches; each vertical or horizontal stroke therefore being 0.0264 inches. A six stroke character height shall be 0.158 inches. A four stroke character width shall be 0.106 inches. The character matrix which includes spacing shall be 24 bits high (0.211 inches) by 16 bits wide (0.141 inches).

For other symbol sizes, see Table III - Symbol Size Control Word Format

FIGURE 12 (Sheet 8)

APPENDIX I

10 TECHNICAL REQUIREMENTS FOR VIDEO DISPLAY FUNCTION

10.1 Scope. - This appendix covers the technical requirement for video display function.

10.2 Applicable Documents. - (none)

10.3 Requirements. -

10.3.1 Function. - The Digital Display Group (DDG) shall provide two video modes of operation:

(a) Video Normal Mode

(b) Video Freeze Mode

10.3.1.1 Video Normal Mode. - The Video Normal mode shall provide a synthetic amplitude versus time ("A" scope format) display of input video signals. The Video Normal display shall be a triggered sweep oscilloscope with selectable time bases, selectable vertical sensitivities and adjustable sync levels. The Video Normal display shall appear in a dedicated area of the cathode-ray-tube (CRT) in place of Frequency/ Azimuth Emitter field (para. 3.4.1.1.1) when the Video Normal mode is selected. Data normally shown on the top and bottom of the Frequency/ Azimuth Emitter field may be simultaneously displayed; however, the contents of this section of the display will be under software control. In addition, when the Video Normal mode is selected, appropriate graticule lines and scale annotation shall be provided. As a minimum, a vertical scale of pulse amplitude (in volts) and a horizontal scale indicating elapsed time since the start of the sweep (in seconds, milli-seconds, or micro-seconds as appropriate) shall be provided. Writing rate shall be 50,000 inches per second.

10.3.1.2 Video Freeze Mode. - The Video Freeze mode shall inhibit processing of new video data therby allowing the continuous presentation of the most recently processed Video Normal data. The Video Freeze shall be displayed as above with attendant scales. No changes of the horizontal or vertical scales shall be possible in the Video Freeze mode.

10.3.1.3 Operation. - The Video Normal and Video Freeze function shall be refreshed as part of the normal refresh cycle.

APPENDIX I

10.3.2 Input Signals. - The DDG shall be provided with two input signals: (1) video signals and (2) an image blank pulse.

(a) The video data signals shall have the following characteristics:

Amplitude: +0.2 to +2.0 volts (referenced to System GND)

Pulse Width: 200 nsec (min) to 25 usec (50% points)

Rise and Fall Time: 10% of pulse width

Transients: the maximum transient amplitude shall be 10 volts and its maximum duration shall be 1% of the pulse width

PRF: 50 Hz to 10 KHz

Source Z: 90 ohms (max.) in parallel with 80 pf

Load Z: 90 ohms (min)

(b) The DDG shall be provided an Image Blank Pulse, which shall inhibit the processing and display of the associated video. The Image Blank Pulse shall have the following characteristics:

UNBLANK level:	+8 to +13 volts DC (referenced to System GND)
BLANK level:	0 to +1 volt DC (referenced to System GND)
Pulse Duration:	7.5 ± 1.0 usec at BLANK level
Transients:	10V max for 1% (max) of the pulse width
Delay from Video Pulse:	1.5 usec (max)
Source Z:	1000 ohms (nom.) in parallel with 80 pf at UNBLANK level 100 ohms (max) in parallel with 80 pf at BLANK level
Load Z:	3300 ohms ± 10%

APPENDIX I

10.3.2(b) (Continued)

As a minimum, the DDG shall not be damaged by any transient specified in 10.3.2 (a) and 10.3.2 (b) on the video pulse or image blank pulse and shall return to normal operation 40 nsec after the end of the transient. The DDG is not required to faithfully reproduce transients as defined above on the video pulse signal.

10.3.3 Controls. - The DDG shall provide the following front panel mounted controls for selecting the options available in the Video Normal-Video Freeze modes:

(a) VIDEO Horizontal Time Base Sel. - the DDG shall provide Horizontal 10 usec, 100 usec, 1 msec, 10 msec, 100 msec, 1 sec and 10 sec sweep rates.

(b) VERT SCALE Sel. - The DDG shall provide a 2.0V full scale, 1.0V full scale and 0.5V full scale vertical sensitivity.

(c) MODE Sel. - the DDG shall operate in Video Normal or Video Freeze mode.

(d) SYNC Level Control - The sweep synchronization level shall be adjustable from approximately 0.1 volt to 0.5 volt.

The routing of data and control pulses to the DDG shall be as shown in Figure 19.

10.3.3.1 Concentric Controls. - Four (4) of the DDG controls shall be grouped in concentric pairs:

(a) MODE/BRT - Outer four-position rotary FRZE, NORM, DATA DISP, STBY mode selector switch and inner single-turn rotary BRT potentiometer.

(b) VERT SCALE/SYNC - Outer three-position rotary 0.5, 1.0, 2.0 volt VERT SCALE selector switch and inner single-turn rotary SYNC potentiometer.

The controls shall be positioned independently without interaction between concentric elements.

APPENDIX I

10.3.4 Time Base Sampling. -

(a) The video time base shall be quantized into the number of time slots listed below. These time slots shall be equally divided across the time base with a tolerance of ± 39 nanoseconds on each sample.

TIME BASE (SWEEP RATE)	TIME SLOTS
10 usec	128
100 usec	512
1 msec	512
10 msec	512
100 msec	512
1 sec	512
10 sec	512

The horizontal trace shall be five inches (5") (min) in length.

(b) The DDG shall be capable of detecting the peak amplitude of a video pulse occurring during a sampling interval. This peak value shall be stored in the memory unit assigned to this sampling interval provided such amplitude was present for more than 78 nsec. If two or more video pulses occur during the sampling interval, the maximum peak amplitude present during the interval shall be stored.

(c) The write (into memory) interval for any sweep rate shall not be less than 90% of the total sweep time (e.g., 9 usec) write interval for the 10 usec sweep).

APPENDIX I

10.3.5 Amplitude Quantization. - The amplitude of the video pulse shall be converted to binary parallel digital representation with 5 bit resolution and not more than 1 least significant bit (LSB) error in the 2.0V full scale and the 1.0V full scale vertical sensitivities. There shall be not more than 2 least significant bits (LSB) error in the 0.5V full scale vertical sensitivity.

10.3.6 Output. - When operating in the Video Normal or Video Freeze Mode the synthetic video presentation shall be centered about the mid point of the CRT in both axes. The display shall consist of a series of marks, one mark for each sampling period. The height of the vertical trace shall be 4 inches, full scale.

10.3.7 BIT. - The Built-In Test (BIT) function of the DDG shall test the Video Normal and Video Freeze modes and present an output on the CRT indicating the results of the tests.

10.3.8 Operating Temperature. - The DDG shall be capable of normal operation while in the Video Normal and Video Freeze modes over the temperature range specified in para. 3.3.9.2.

10.3.9 External Clock. - Provisions shall be made to disable clocks of the synthesized video circuitry and enable the use of a substitute external clock.

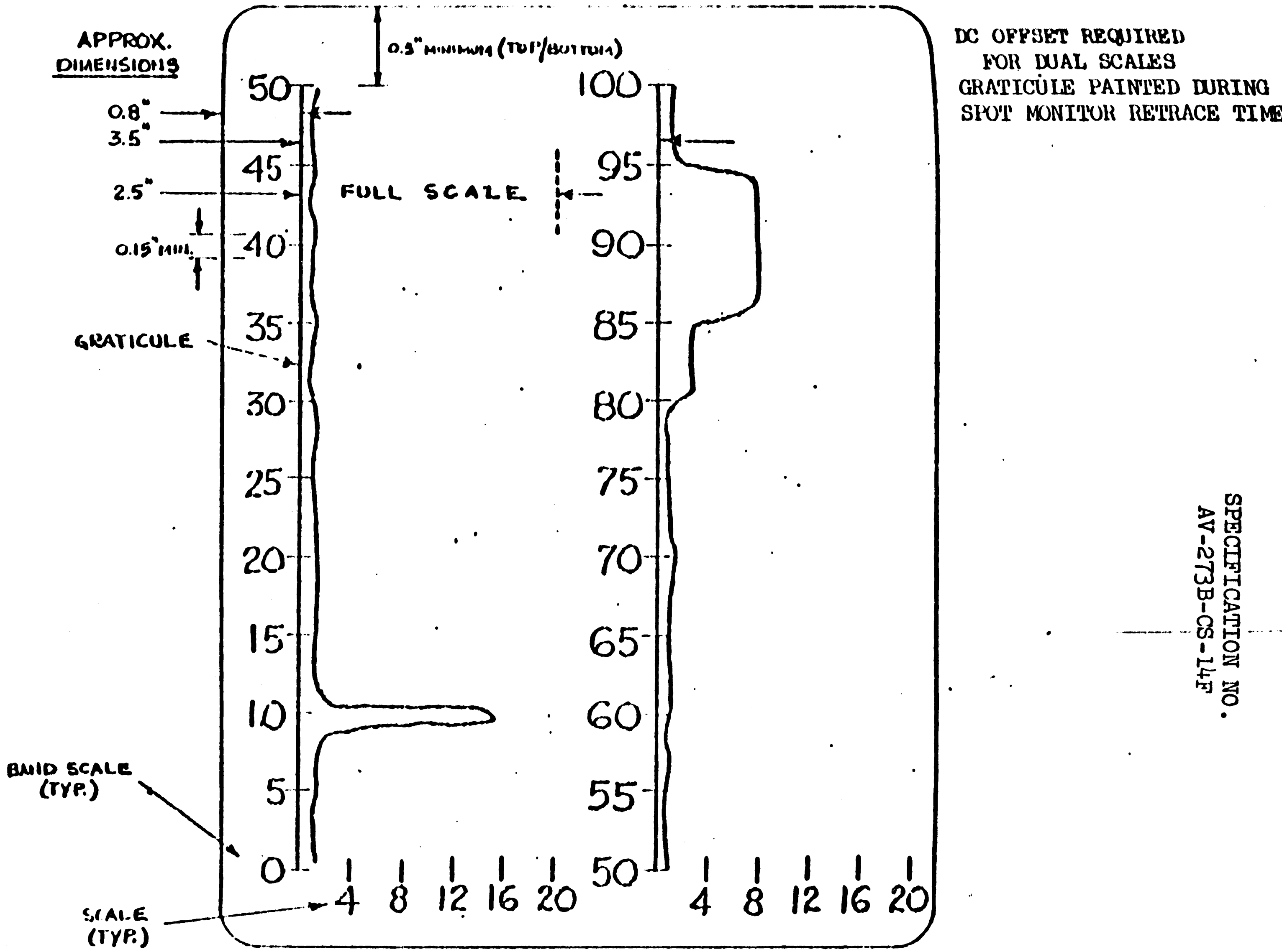

APPROX. DIMENSIONS
0.8"
3.5"
2.5"
0.15" MIN.
GRATICULE
BAND SCALE (TYP.)
SCALE (TYP.)
0.5" MINIMUM (TOP/BOTTOM)
FULL SCALE
50
45
40
35
30
25
20
15
10
5
0
100
95
90
85
80
75
70
65
60
55
50
4 8 12 16 20
4 8 12 16 20
DC OFFSET REQUIRED
FOR DUAL SCALES
GRATICULE PAINTED DURING
SPOT MONITOR RETRACE TIME

FIGURE 18

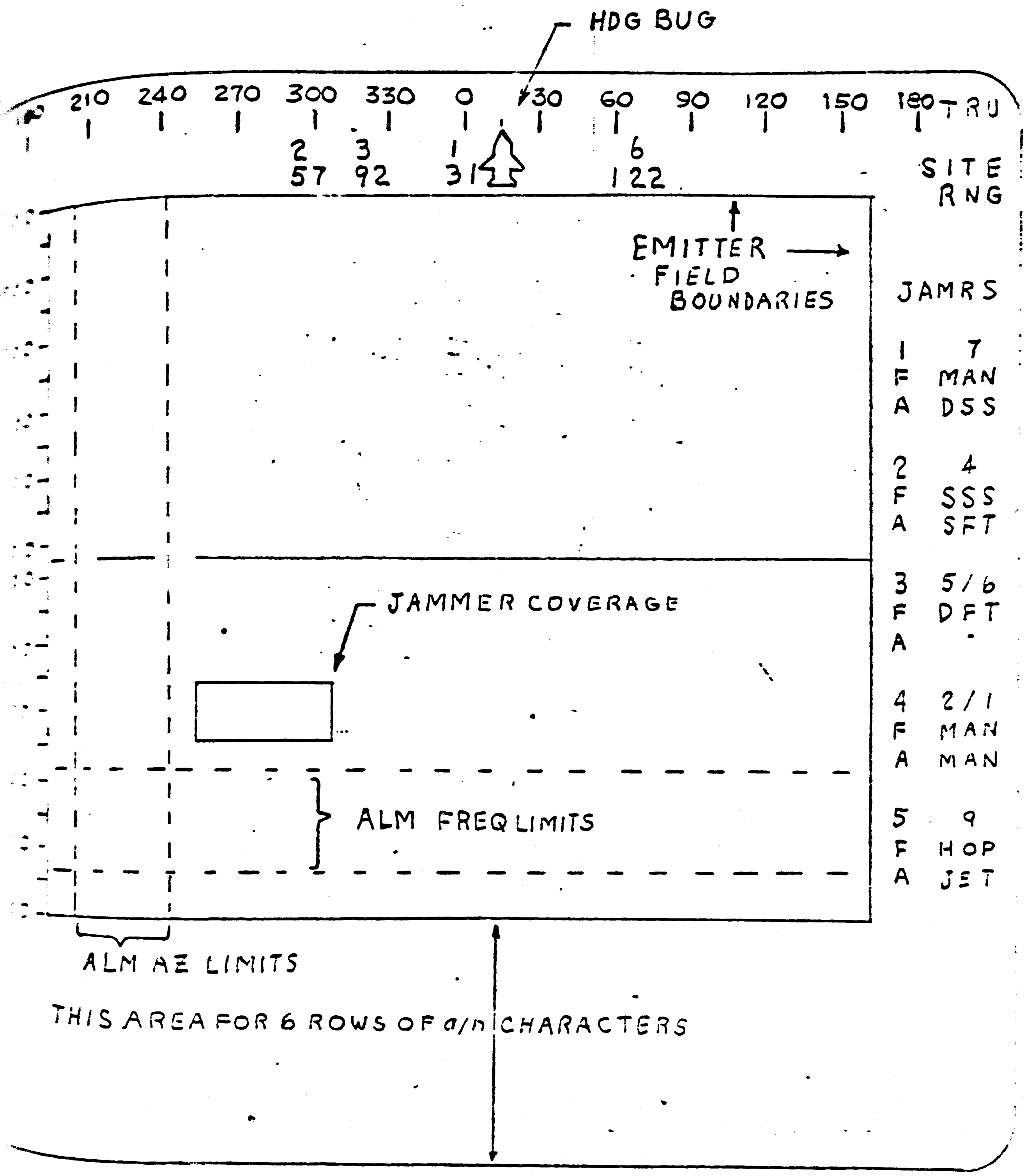
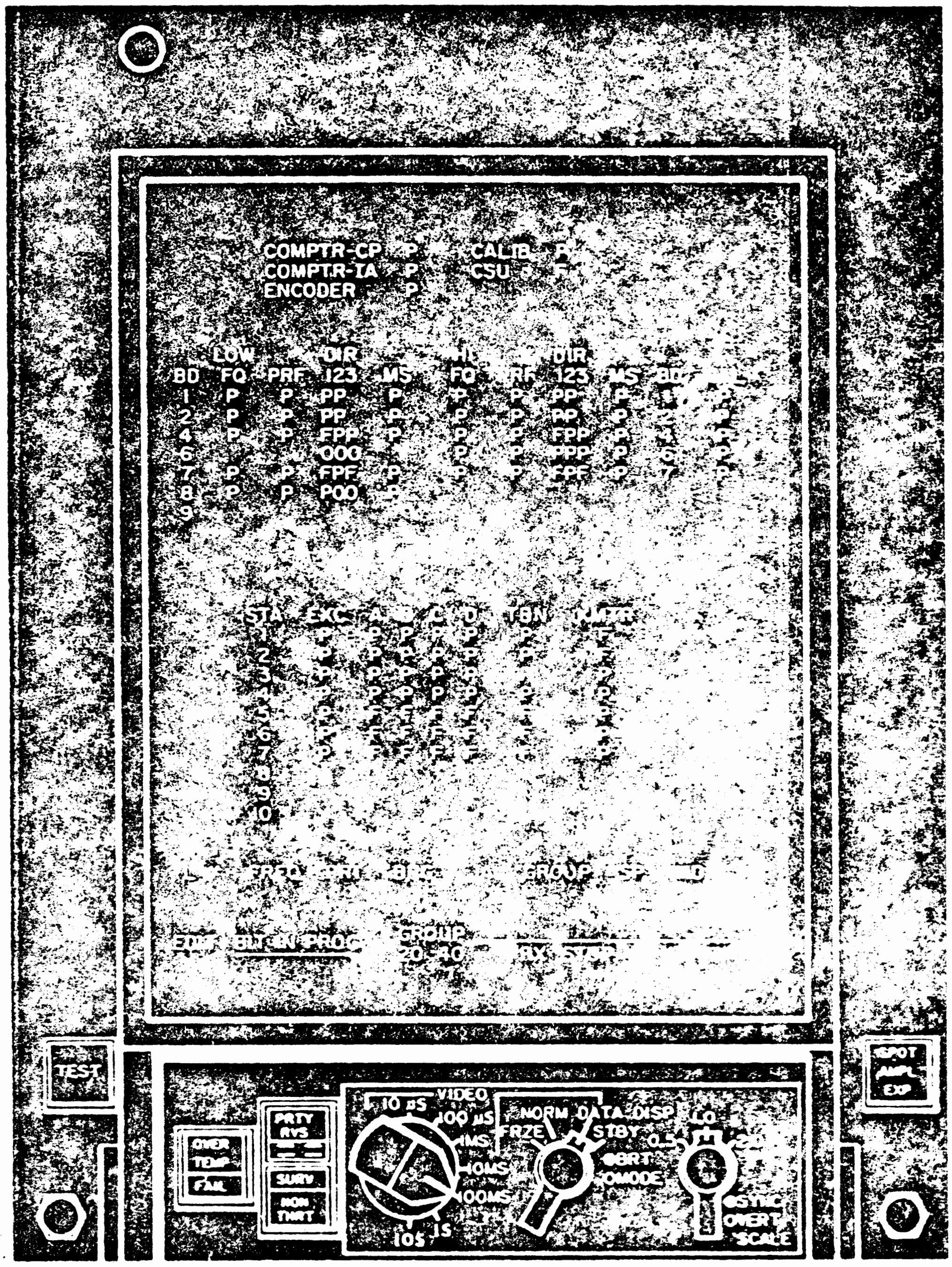


FIGURE 11

SITUATION DISPLAY FORMAT

2 cm = 7 ch
11.5 cm/screen
= 40 ch/screen

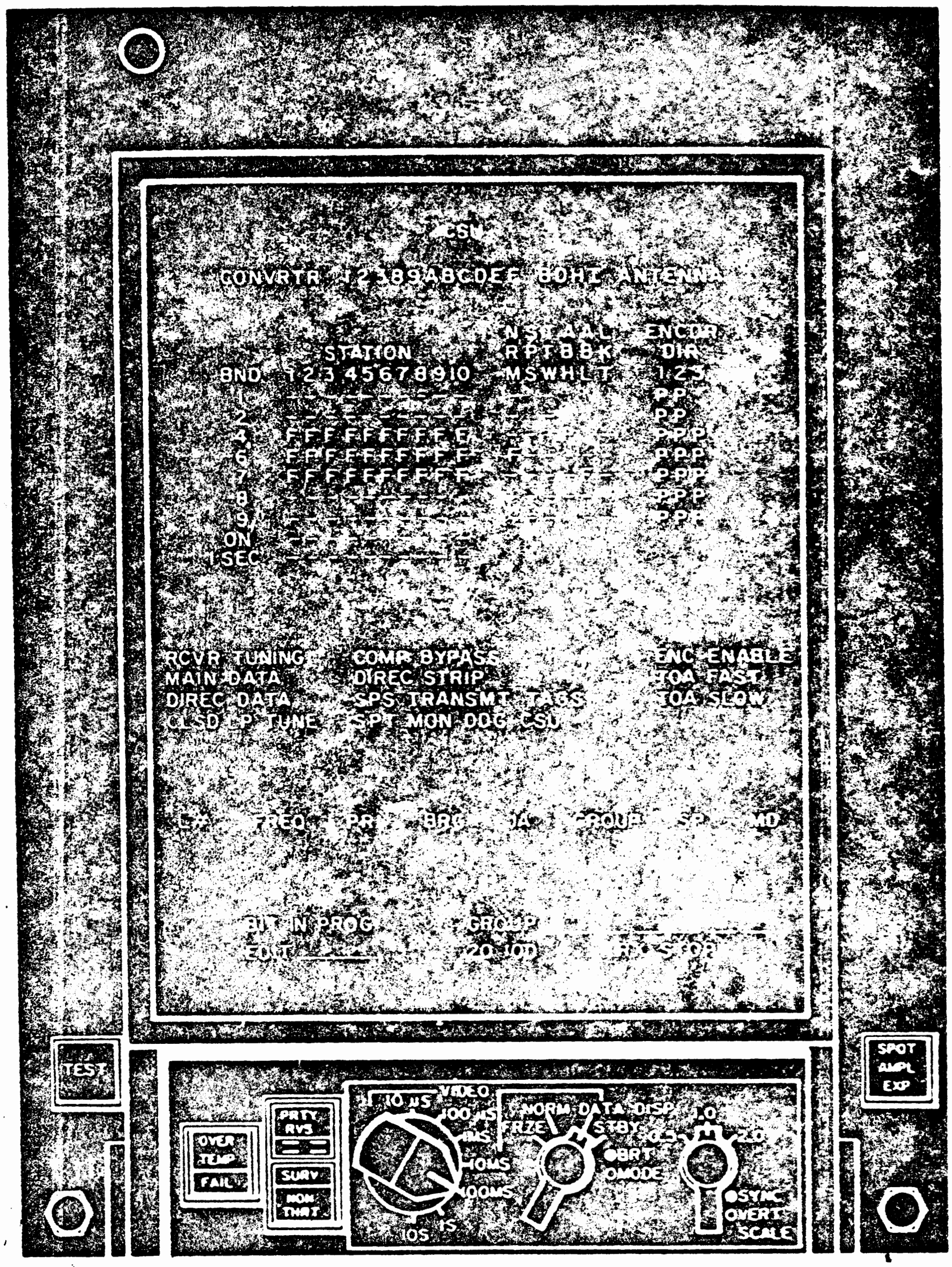
SYSTEM BIT DISPLAY



1EF111A-1-5

Figure 1-55.

CSU BIT DISPLAY



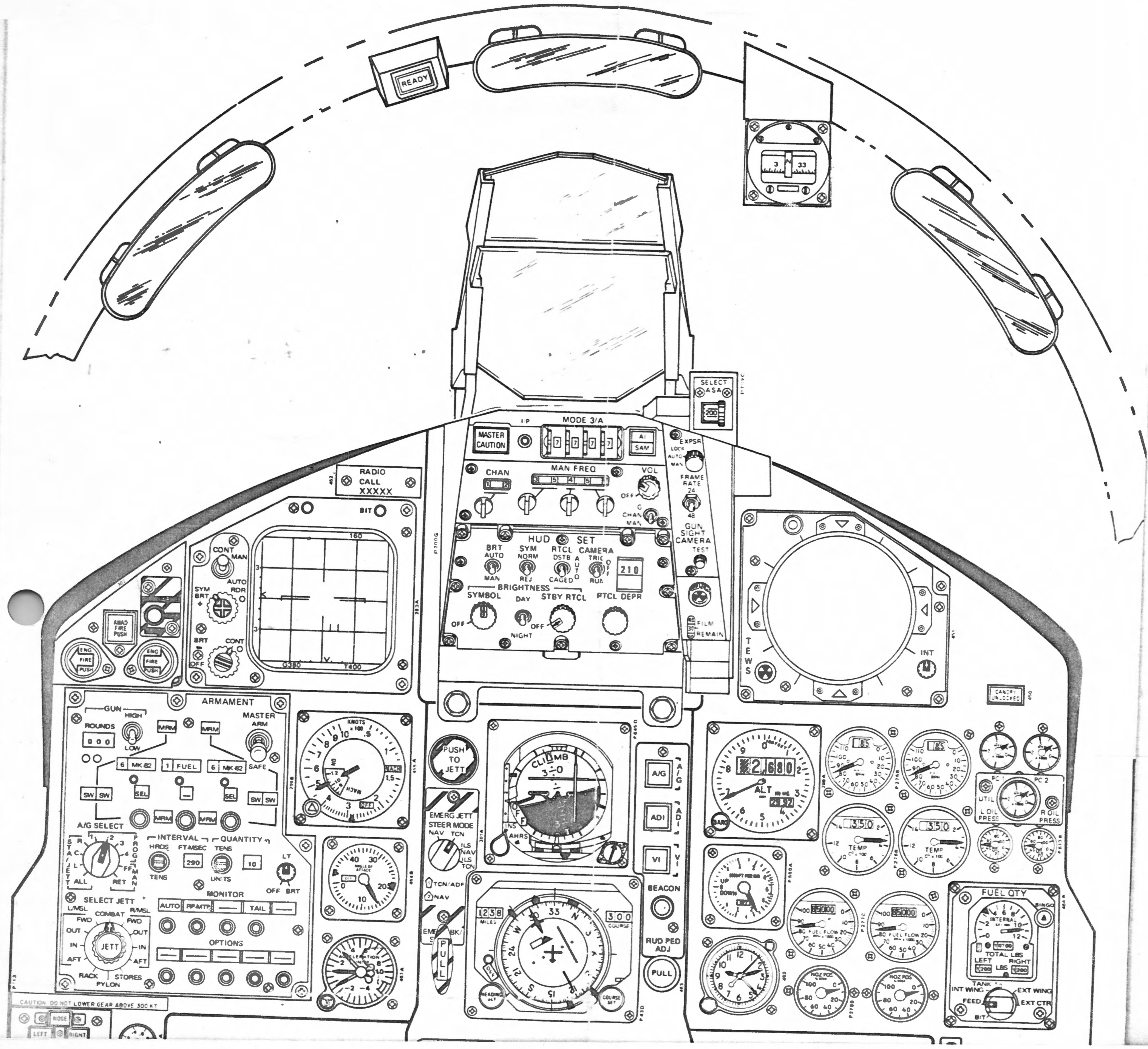
1EF111A-1-60

Figure 1-56.

Tab - “F-15 Display Data”

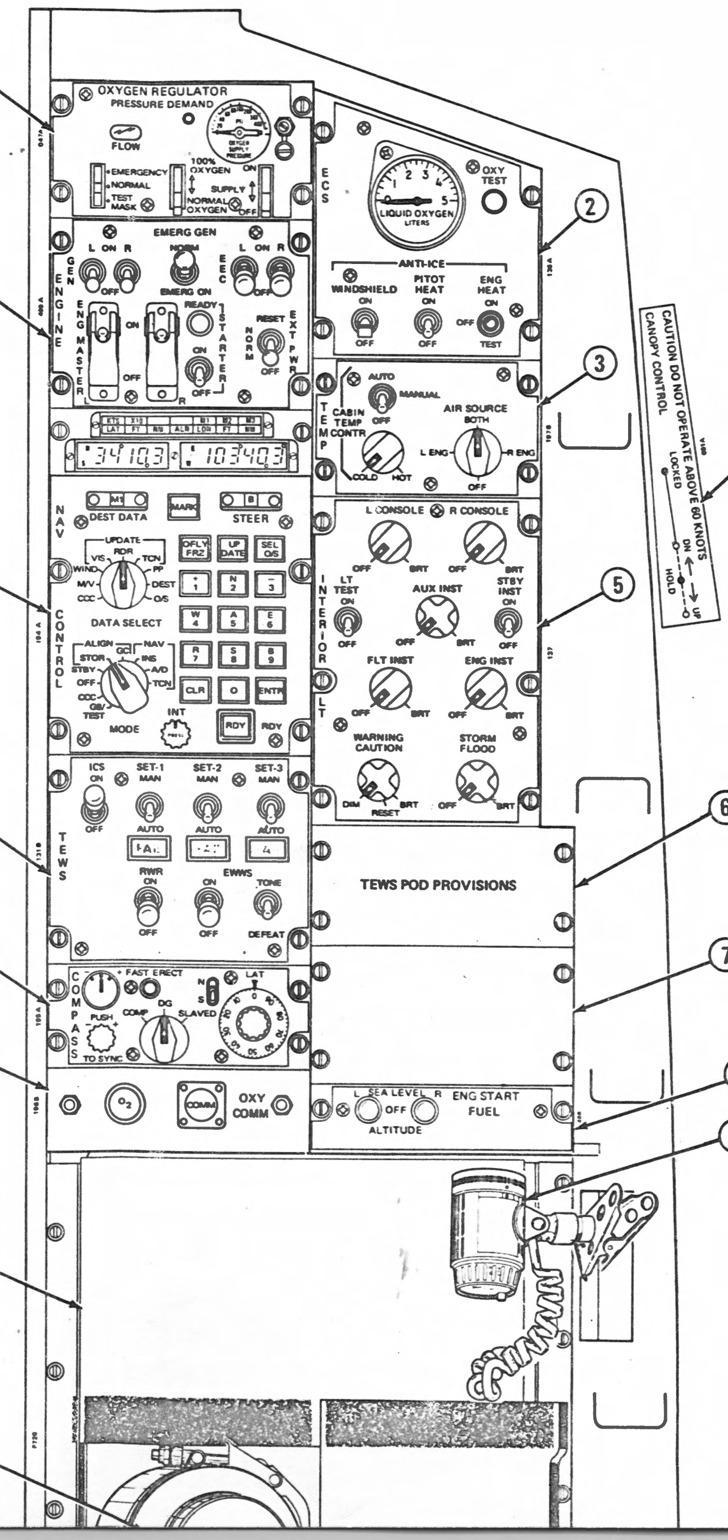
F15 HP

RD COCKPIT

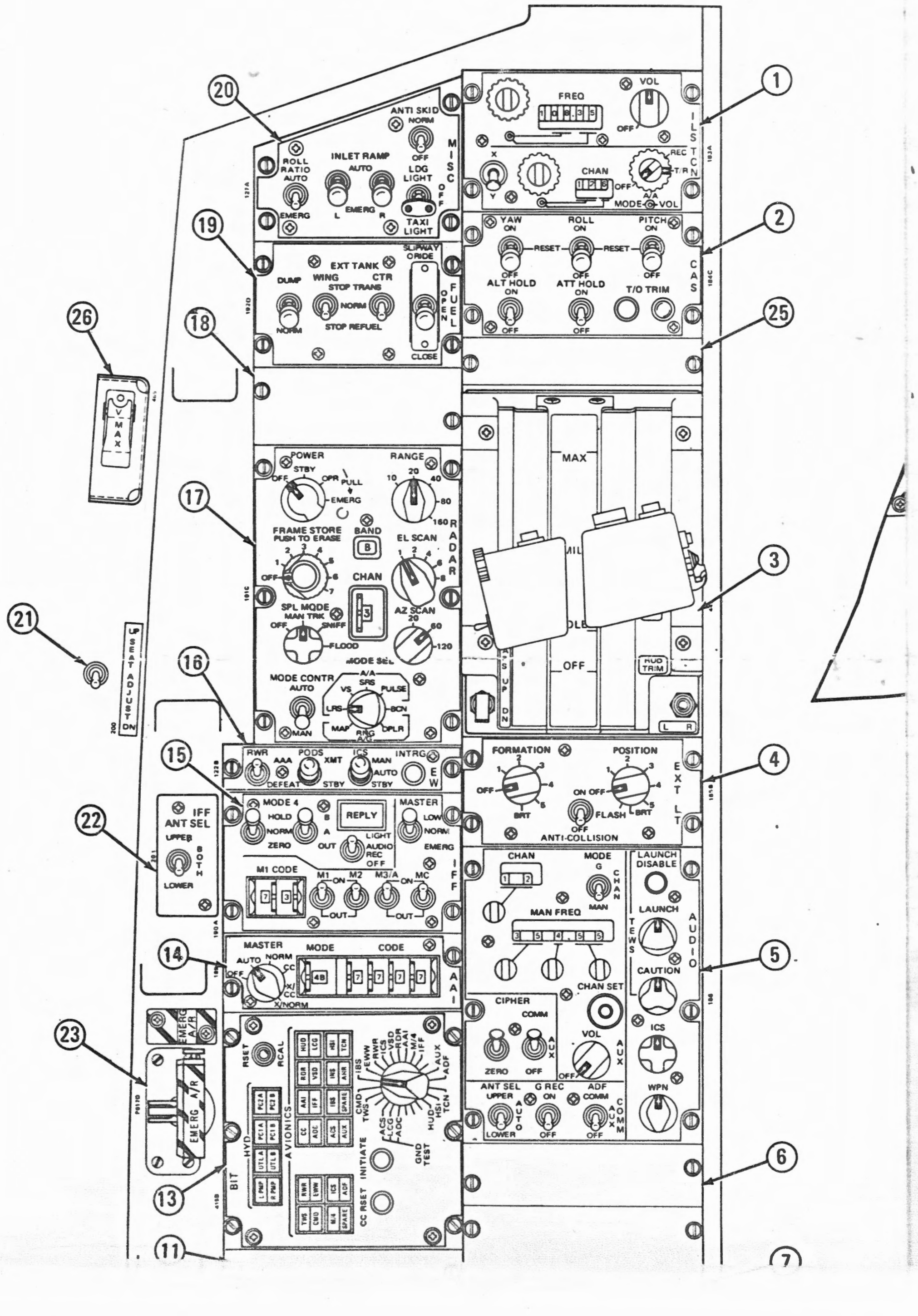


1

1. OXYGEN REGULATOR PANEL
2. ENVIRONMENTAL CONTROL SYSTEMS PANEL
3. CABIN TEMPERATURE CONTROL PANEL
4. CANOPY CONTROL
5. INTERIOR LIGHTS CONTROL PANEL
6. TEWS POD CONTROL PANEL
7. BLANK PANEL
8. UTILITY LIGHT
9. VACUUM BOTTLE
10. STOWAGE COMPARTMENT
11. OXYGEN/COMMUNICATIONS OUTLET PANEL
12. COMPASS CONTROL PANEL
13. TEWS CONTROL PANEL
14. NAVIGATION CONTROL PANEL
15. ENGINE CONTROL PANEL
16. ENGINE START PANEL



1. NAVIGATION AIDS PANEL
2. CONTROL AUGMENTATION SYSTEM (CAS) PANEL
3. THROTTLE QUADRANT
4. EXTERIOR LIGHTS CONTROL PANEL
5. INTEGRATED COMMUNICATIONS CONTROL PANEL
6. BLANK PANEL
7. BLANK PANEL
8. ANTI-G PANEL
9. BLANK PANEL
10. BLANK PANEL
11. BLANK PANEL
12. GROUND POWER PANEL
13. BIT PANEL
14. AAI CONTROL PANEL
15. IFF CONTROL PANEL
16. TEWS CONTROL PANEL
17. RADAR CONTROL PANEL
18. BLANK PANEL
19. FUEL CONTROL PANEL
20. MISCELLANEOUS CONTROL PANEL
21. SEAT ADJUST SWITCH
22. IFF ANTENNA SELECT SWITCH
23. EMERGENCY AIR REFUELING CONTROL
24. ARMAMENT SAFETY OVERRIDE SWITCH
25. BLANK PANEL
26. V_{MAX} SWITCH



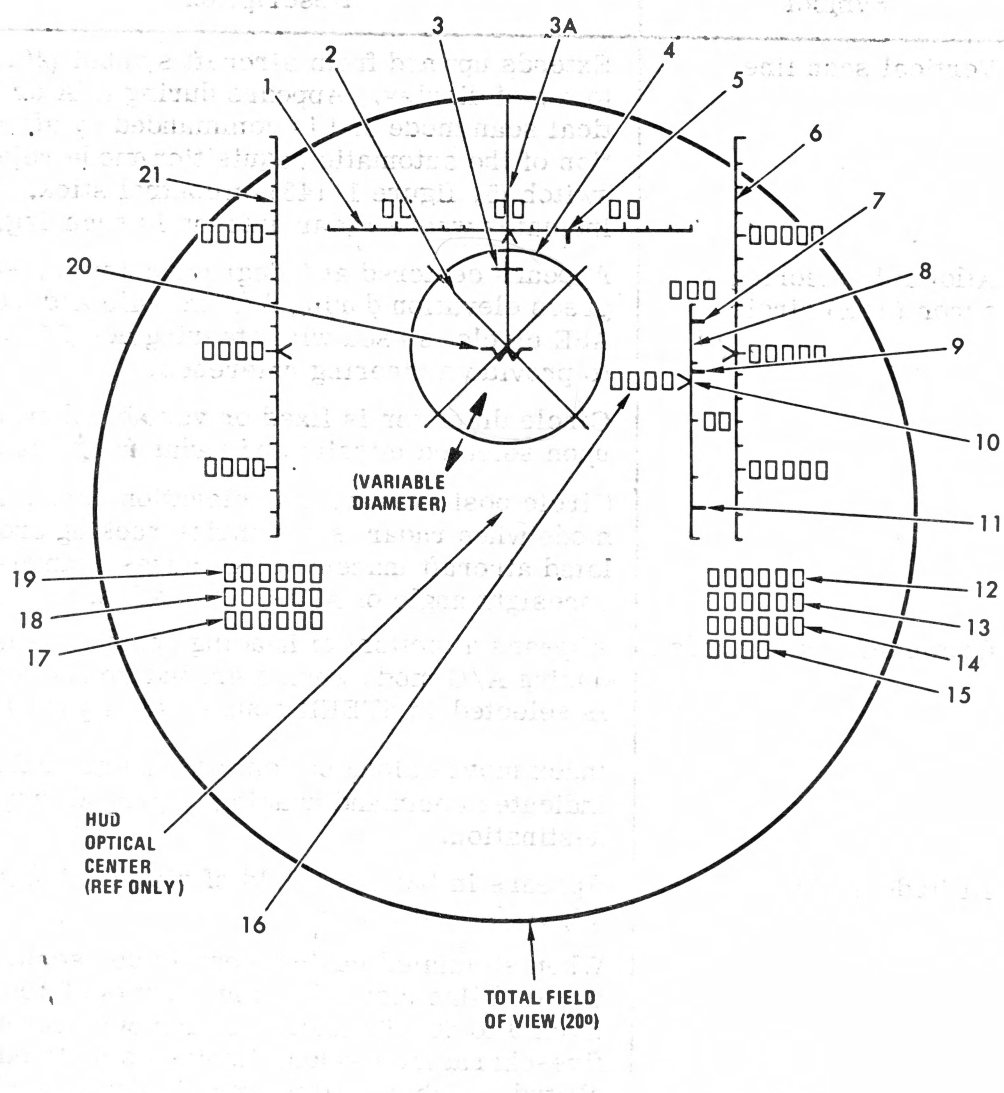


Figure 1-145. HUD Symbology (Sheet 1 of 5)

Vis indicator   attitude director indic

1-43. HEAD-UP DISPLAY. The HUD is an electro-optical (EO) sight system that displays symbolic flight and attack steering information and projects it into the pilot's field of view. The mode and type of displays available are a function of the simulated aircraft operating mode (A/A, VI, A/G, ADI) and the munitions selected.

Air to air   Air to Gnd

1-44. The symbols and windows which can be displayed on the HUD are shown in figure 1-145 and described in table 1-128. The operating modes and displays available are described in paragraphs 1-45 through 1-55. The symbols and windows displayed on the cockpit HUD are also displayed on the instructor console center CRT HUD display page (figure 1-53).

Table 1-128. HUD Symbology

Index No. (fig. 1-145)	Symbol	Description
1 (sh 1)	Heading scale	Appears in top center field of view during VI, A/G, ADI, and all A/A modes, except SRM — Short range missile supersearch and boresight modes. Scale is a horizontal line marked in increments of 2 degrees from 0 to 360 degrees. At each 10 degree mark, a two-character readout displays simulated aircraft heading in degrees multiplied by 10. Scale and readouts move horizontally and increase in value from left to right. A fixed pointer below center of scale indicates aircraft heading.
2 (sh 1)	Break X	Appears centered at 0 degrees azimuth, +4 degrees elevation during A/A missile and VI modes. Symbol indicates that simulated aircraft is too close to target and should break off attack or approach. During AIM-9 missile attacks, symbol flashes. During AIM-7 missile attacks, symbol is constant while missile is in flight and flashes when missile flight time elapses.
3 (sh 1)	Gun cross	Appears at 0 degrees azimuth, + 6 degrees elevation when MASTER switch (6, figure 1-123) is in ARM position and gun is ready for firing. Symbol indicates that gun projectile aim point is 2250 feet.

Table 1-128. HUD Symbology (Continued)

Index No. (fig. 1-145)	Symbol	Description
3A (sh 1)	Vertical scan line	Extends upward from aircraft symbol (20, sheet 1) to top of display. Appears during A/A or VI vertical scan mode and is commanded by aft activation of the automatic acquisition/mode reject switch (5, figure 1-143) on control stick. Symbol indicates where radar antenna is scanning.
4 (sh 1)	Allowable steering error (ASE) circle	Appears centered at 0 degrees azimuth, +4 degrees elevation during A/A missile and VI modes. ASE circle is used with steering dot (35, sheet 4) to provide a steering reference.
		Circle diameter is fixed or variable depending upon selected missile and radar range data.
		Circle position varies in elevation during A/A SRM mode when radar is not angle-tracking and simulated aircraft maneuvering causes changes in boresight angle of AIM-9L missiles.
5 (sh 1)	Command heading index	Appears at bottom of heading scale (1, sheet 1) during A/G mode when a ground target destination is selected on STEER counter (5, figure 1-140).
		Index moves along bottom of heading scale and indicates command heading to ground target destination.
6 (sh 1)	Altitude scale	Appears in far right field of view during A/A, VI, A/G, and ADI modes.
		When simulated landing gear is up, scale is a vertical line marked in increments of 100 feet from 0 to 80,000 feet. At each 500-foot mark, a five-character readout displays simulated aircraft altitude. When landing gear is down, scale is marked in increments of 20 feet with five-character readouts every 100 feet.
		Scale and readouts move vertically and increase in value from bottom to top. A fixed pointer at center of scale indicates altitude.
7 (sh 1)	R max 1 index	Appears at right side of radar range scale (8, sheet 1) during A/A and VI track modes.
		Index moves along right side of scale and indicates maximum launch range of MRM against a nonmaneuvering target and maximum launch range of SRM against any type of target.

Table 1-128. HUD Symbology (Continued)

Index No. (fig. 1-145)	Symbol	Description
8 (sh 1)	Radar range scale	Appears in right field of view to the left of altitude scale (6, sheet 1) during A/A and VI modes when simulated radar set is tracking a target. Radar range selected by RANGE switch (2, figure 1-83) is displayed at top of scale on a three-character readout. Scale is a vertical line marked in four equal increments that represent nautical miles. Increment values are equal to one-fourth of the selected radar range. Two-character readout at center of scale displays one-half the value of selected radar range.
9 (sh 1)	R max 2 index	Appears at right side of radar range scale (8, sheet 1) below R max 1 index (7, sheet 1) during A/A MRM and VI track modes. Index moves along right side of scale and indicates maximum launch range against a maneuvering target. Symbol does not appear in SRM mode.
10 (sh 1)	Range to target pointer	Appears at left side of radar range scale (8, sheet 1) during A/A and VI modes. Pointer moves along left side of scale and indicates range to simulated target.
11 (sh 1)	R min index	Appears at right side of radar range scale (8, sheet 1) during A/A and VI track modes. Index moves along right side of scale and indicates range at which simulated missile explosion can cause damage to attacking aircraft.
12 (sh 1)	Window 3	A six-character alphanumeric readout positioned in far right field of view below radar range scale (8, sheet 1). a. In A/A missile modes, IN RNG is displayed when target being tracked is in range of selected simulated missile. IN RNG flashes when target range is greater than R max 2, but less than R max 1 with MRM selected or when target range is between R max and R min with SRM selected.

Table 1-128. HUD Symbology (Continued)

Index No. (fig. 1-145)	Symbol	Description
12 (cont) (sh 1)	Window 3 (cont)	b. In A/A missile modes, NO ZN is displayed when aircraft-to-target range is such that weapon firing is not possible. c. In A/A missile and VI modes, MN TRK, SNIFF, or FLOOD is displayed to indicate simulated radar set special mode. d. In ADI mode, NAV, TCN, ILS-N, or ILS-T is displayed to indicate ADI steering mode. e. When HUD titler data are being displayed, first and second characters indicate month, third and fourth characters indicate day, and fifth and sixth characters indicate year.
13 (sh 1)	Window 4	A six-character alphanumeric readout positioned in far right field of view below window 3 (12, sheet 1). a. In A/A and VI modes, MEM is displayed when simulated radar set maintains tracking by using memory capabilities. b. In A/A and VI modes, JAM, AOJ, or HOJ is displayed when radar set is being jammed or when radar set is operating in angle-of-jam or home-on-jam mode. c. In A/G mode, B, a number between one and 11, M1, M2, or M3 is displayed to indicate ground target destination selected on STEER counter (5, figure 1-140). d. In ADI mode, B, a number between one and 11, M1, M2, or M3 is displayed to indicate ground target destination if STEER MODE switch (3, figure 1-118) is in NAV or ILS/NAV position. e. When HUD titler data are being displayed, first and second characters indicate mission number and third through sixth characters indicate simulated aircraft number.

Table 1-128. HUD Symbology (Continued)

Index No. (fig. 1-145)	Symbol	Description
13 (cont) (sh 1)	Window 4 (cont)	f. In A/A and VI modes, radar range is displayed when radar is range tracking. Range is given to the nearest nautical mile up to a maximum of 86 nmi. Display is overridden by MEM, AOJ, HOJ, or JAM displays. First character is blank. Second and third characters display radar range. Fourth character is blank. Fifth and sixth characters display NM.
14 (sh 1)	Window 5	A six-character alphanumeric readout positioned in far right field of view below windows 3 and 4 (12 and 13, sheet 1). a. In A/A MRM mode, HD ALT is displayed when attack situation requires that present altitude be maintained. b. In A/G automatic and A/G CDIP modes, time remaining before weapon release is displayed. First and second characters indicate number of seconds. Third, fourth, and fifth characters indicate SEC. c. In A/A MRM mode, the predicted AIM-7 time-of-flight is displayed to indicate seconds it would take for weapon to impact target when target range is between R max 1 and R min. Predicted time-of-flight readout is continuously updated until missile launch. At missile launch, actual time-of-flight countdown to zero seconds in real time begins. Actual time-of-flight readout flashes to distinguish it from predicted time-of-flight readout. A maximum of 99 seconds can be displayed. First and second characters indicate number of seconds. Third character is blank. Fourth, fifth, and sixth characters indicate SEC. d. When HUD titler data are being displayed, first through fourth characters indicate squadron number and fifth and sixth characters indicate pilot code number.

Table 1-128. HUD Symbology (Continued)

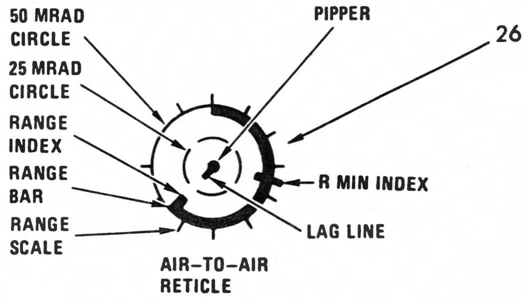
Index No. (fig. 1-145)	Symbol	Description
14 (cont) (sh 1)	Window 5 (cont)	e. In A/A and VI modes, selected TACAN station range is displayed to the nearest tenth of a nautical mile. First through fourth characters indicate number of miles or are blank; fifth character indicates a decimal point or is blank; and sixth character indicates tenths of a nautical mile or is blank. f. In ADI mode, NAV, TCN, ILS-T, or ILS-N destination range is displayed to the nearest tenth of a nautical mile. First through fourth characters indicate number of miles or are blank; fifth character indicates a decimal point or is blank; and sixth character indicates tenths of a nautical mile or is blank.
15 (sh 1)	Window 6	A four-character alphanumeric readout positioned in far right field of view below windows 3, 4, and 5 (12, 13, and 14, sheet 1). a. In ADI mode, CSET is displayed when an ILS steer mode is selected. CSET flashes 2.5 times per second for 10 seconds to indicate course is being set by simulated central computer. After 10 seconds, CSET disappears to indicate course is set. b. In ADI mode, GSUP is displayed when ILS is selected to indicate simulated aircraft is below landing approach. No display appears when aircraft is on valid glideslope. c. In ADI mode, GSDN is displayed when ILS is selected to indicate simulated aircraft is above landing approach. No display appears when aircraft is on valid glideslope. d. When HUD titler data are being displayed, first through fourth window characters indicate flight number. e. In A/A SRM mode, UNC is displayed when SRM missile is manually commanded to uncage by depressing the SRM uncage/steering maneuvering mode switch (7, figure 1-143) on control stick.

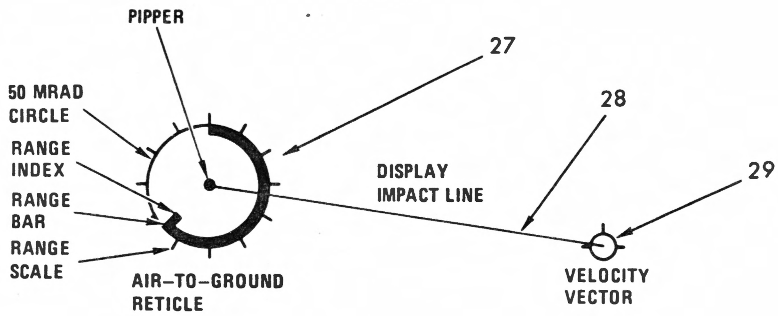
Table 1-128. HUD Symbology (Continued)

Index No. (fig. 1-145)	Control/Indicator	Function
15 (cont) (sh 1)	Window 6 (cont)	f. In PSP configuration only, RAM is displayed when radar is in RAM search or RAM track mode.
16 (sh 1)	Window 1	A four-character alphanumeric readout positioned to the left of range to target pointer (10, sheet 1). Window moves vertically with pointer. a. In A/A missile and VI modes, target closing rate is displayed. First character indicates either a minus (-) sign or a number. Second through fourth characters indicate numbers. b. When HUD titler data are being displayed, DATE is displayed.
17 (sh 1)	Window 8	A six-character alphanumeric readout positioned in far left field of view below windows 2 and 7 (19 and 18, sheet 1). a. In VI mode, simulated target airspeed Mach number is displayed when weapon/mode switch (3, figure 1-69) is in SRM or MRM position and simulated radar set is tracking a target. First and second characters indicate T and M respectively. Third, fourth, and fifth characters indicate a number, a decimal point, and a number respectively. b. In all modes, except VI mode, simulated aircraft g's are displayed to the nearest tenth. First character gives no indication when aircraft g's are positive. When aircraft g's are negative, first character indicates a minus (-) sign. Second, third, and fourth characters indicate a number, a decimal point, and a number respectively. Fifth character indicates G.
18 (sh 1)	Window 7	A six-character alphanumeric readout positioned in far left field of view below window 2 (19, sheet 1). In A/A and VI modes, simulated aircraft airspeed Mach number is displayed. First and second characters indicate a number and a decimal point respectively. Third through fifth characters indicate numbers.

Table 1-128. HUD Symbology (Continued)

Index No. (fig. 1-145)	Symbol	Description
19 (sh 1)	Window 2	A six-character alphanumeric readout positioned in far left field of view below airspeed scale (21, sheet 1). a. In A/A gun mode, number of rounds available is displayed. First through sixth window characters indicate numbers. When last round is in gun, XXX is displayed. b. In A/A and VI MRM modes, number of AIM-7 missiles in standby or ready status is displayed. Second character indicates M. Fourth character indicates a number. First, third, fifth, and sixth characters are blank. c. In A/A and VI SRM modes, number of AIM-9 missiles in standby or ready status is displayed. Second character indicates S. Fourth character indicates a number. First, third, fifth, and sixth characters are blank. d. In ADI mode, MKR is displayed when an ILS marker is overflown.
20 (sh 1)	Aircraft symbol	Appears centered in fixed position at 0 degrees azimuth, +4 degrees elevation during A/A missile, ADI, and VI modes and during A/G mode when velocity vector (29, sheet 3) data are invalid. Symbol provides a reference for flight director symbol (32, sheet 4) in ADI mode when velocity vector is not present. If simulated central computer fails, aircraft symbol appears automatically.
21 (sh 1)	Airspeed scale	Appears in far left field of view during A/A, VI, A/G, and ADI modes. Scale is a vertical line marked in increments of 10 knots. At each 50-knot mark, a four-character readout displays simulated airspeed. Scale and readouts move vertically and increase in value from top to bottom. A fixed pointer at center of scale indicates airspeed.





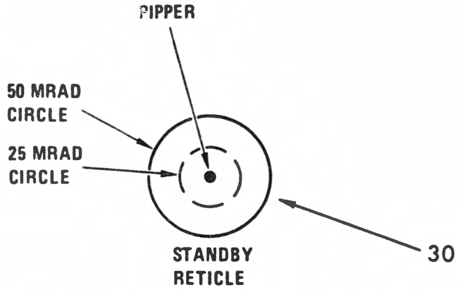


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Figure 1-145. HUD Symbology (Sheet 3)

Table 1-128. HUD symbology (Continued)

Index No. (fig. 1-145)	Symbol	Description
26 (cont) (sh 3)	Air-to-air reticle (cont)	The pipper is an optical sight aim dot for air-to-air gunfire. When simulated aircraft is maneuvered to superimpose pipper on simulated target, gunfire and target will meet at the point in space determined by computed prediction angle. The 50 MRAD circle circumscribes pipper and provides a reference for locating pipper on HUD combining glass. The 25 MRAD circle appears when radar is not locked on to a target and provides a fixed range solution. The range scale is marked in increments of 1000 feet around outer perimeter of 50 MRAD circle. The range bar extends clockwise around the inside of 50 MRAD circle and indicates radar range-to-target from 0 (12 o'clock position) around to 12,000 (12 o'clock position) feet. The range bar appears during AIM-9L SRM track display and VI modes when radar range is less than 12,000 feet. In SRM mode, R min index appears on range bar at the range that corresponds to the R min value. In AIM-9L manual boresight mode, range bar does not appear. The range index is located at the end of range bar. The lag line is displayed in A/A gun mode when reticle dynamic error is greater than 3 MRAD's. Length of lag line indicates magnitude of error. Direction of line indicates direction of error. During secondary mode, complete air-to-air reticle is displayed at all times.
27 (sh 3)	Air-to-ground reticle	Appears during A/G mode. Reticle position varies over total field of view to indicate the computed prediction angle.

Table 1-128. HUD Symbology (Continued)

Index No. (fig. 1-145)	Symbol	Description
27 (cont) (sh 3)	Air-to-ground reticle (cont)	Reticle is automatically positioned to velocity vector (29, sheet 3) during A/G automatic mode; to computed weapon impact point during A/G CDIP mode; to weapon boresight when electro-optical (EO) weapon is selected; and to weapon seeker head position when an infrared (IR) guided weapon is selected. Reticle is manually positioned using RTCL DEPR control (6, figure 1-94) during A/G direct and A/G manual modes. Reticle consists of a pipper, 50 MRAD circle, range scale, range bar, and range index. The pipper is an optical sight aim dot for air-to-ground weapon release. When simulated aircraft is maneuvered to superimpose pipper on simulated target, weapon will strike target at the point determined by computed prediction angle. Pipper indicates impact point in A/G CDIP mode. The 50 MRAD circle circumscribes pipper and provides a reference for locating pipper on HUD combining glass. The range scale is marked in increments of 1000 feet around outer perimeter of 50 MRAD circle. The range bar extends clockwise around the inside of 50 MRAD circle and indicates radar range-to-target from 0 (12 o'clock position) around to 12,000 (12 o'clock position) and around again to 24,000 (12 o'clock position) feet. The range index is located at end of range bar to indicate the range bar end when range-to-target is greater than 12,000 feet position.
28 (sh 3)	Display impact line	Appears during A/G mode to aid in positioning A/G reticle (27, sheet 3) on simulated target. Impact line varies in length and extends from the center of velocity vector (29, sheet 3) to the center of A/G reticle (27, sheet 3).

Table 1-128. HUD Symbology (Continued)

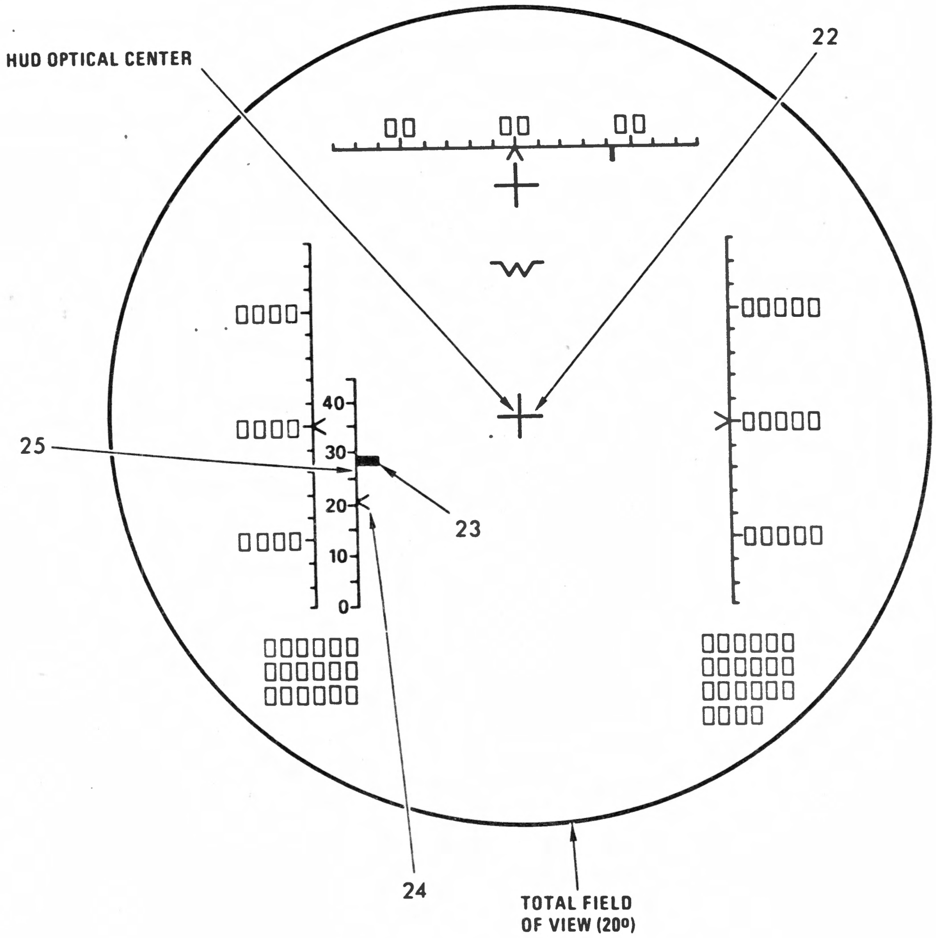
Index No. (fig. 1-145)	Symbol	Description
29 (sh 3).	Velocity vector	Appears in all modes. Vector position varies over a 17 degree field of view in ADI, VI, and A/A modes. Position varies over a 16 degree field of view in A/G mode. Vector indicates simulated aircraft flight path angle and is used as a reference for pitch scale (40, sheet 5). Vector flashes (1.4 seconds on and 0.2 second off) if data to simulated central computer are degraded or vector is caged. In ADI mode, vector is caged/uncaged by momentarily pressing reticle stiffen/SRM reject switch (9, figure 1-69).
30 (sh 3)	Standby reticle	Appears in A/A and A/G modes as a backup reticle if air-to-air reticle (26, sheet 3) or air-to-ground reticle (27, sheet 3) is missing due to simulated central computer or HUD set malfunction. Reticle position varies 0 degrees in azimuth and 0 to -270 MRAD's in elevation. Reticle consist of a pipper, 50 MRAD circle, and 25 MRAD circle. The pipper is an optical sight aim dot for air-to-air gun fire or air-to-ground weapon release. The 50 MRAD circle circumscribes pipper, providing a reference for locating pipper on HUD combining glass. The 25 MRAD circle circumscribes pipper, and provides a fixed range solution. Reticle does not have radar range or lag line display capabilities. Reticle is not displayed on instructor console center CRT HUD display page (figure 1-53).
31 (sh 4)	SRM seeker position or boresight cue	A constant-diameter circle that appears during A/A SRM mode and indicates which direction the simulated AIM-9 missile seeker head is pointed.

Table 1-128. HUD Symbology (Continued)

Index No. (fig. 1-145)	Symbol	Description
27 (cont) (sh 3)	Air-to-ground reticle (cont)	Reticle is automatically positioned to velocity vector (29, sheet 3) during A/G automatic mode; to computed weapon impact point during A/G CDIP mode; to weapon boresight when electro-optical (EO) weapon is selected; and to weapon seeker head position when an infrared (IR) guided weapon is selected. Reticle is manually positioned using RTCL DEPR control (6, figure 1-94) during A/G direct and A/G manual modes. Reticle consists of a pipper, 50 MRAD circle, range scale, range bar, and range index. The pipper is an optical sight aim dot for air-to-ground weapon release. When simulated aircraft is maneuvered to superimpose pipper on simulated target, weapon will strike target at the point determined by computed prediction angle. Pipper indicates impact point in A/G CDIP mode. The 50 MRAD circle circumscribes pipper and provides a reference for locating pipper on HUD combining glass. The range scale is marked in increments of 1000 feet around outer perimeter of 50 MRAD circle. The range bar extends clockwise around the inside of 50 MRAD circle and indicates radar range-to-target from 0 (12 o'clock position) around to 12,000 (12 o'clock position) and around again to 24,000 (12 o'clock position) feet. The range index is located at end of range bar to indicate the range bar end when range-to-target is greater than 12,000 feet position.
28 (sh 3)	Display impact line	Appears during A/G mode to aid in positioning A/G reticle (27, sheet 3) on simulated target. Impact line varies in length and extends from the center of velocity vector (29, sheet 3) to the center of A/G reticle (27, sheet 3).

Table 1-128. HUD Symbology (Continued)

Index No. (fig. 1-145)	Symbol	Description
29 (sh 3)	Velocity vector	Appears in all modes. Vector position varies over a 17 degree field of view in ADI, VI, and A/A modes. Position varies over a 16 degree field of view in A/G mode. Vector indicates simulated aircraft flight path angle and is used as a reference for pitch scale (40, sheet 5). Vector flashes (1.4 seconds on and 0.2 second off) if data to simulated central computer are degraded or vector is caged. In ADI mode, vector is caged/uncaged by momentarily pressing reticle stiffen/SRM reject switch (9, figure 1-69).
30 (sh 3)	Standby reticle	Appears in A/A and A/G modes as a backup reticle if air-to-air reticle (26, sheet 3) or air-to-ground reticle (27, sheet 3) is missing due to simulated central computer or HUD set malfunction. Reticle position varies 0 degrees in azimuth and 0 to -270 MRAD's in elevation. Reticle consist of a pipper, 50 MRAD circle, and 25 MRAD circle. The pipper is an optical sight aim dot for air-to-air gun fire or air-to-ground weapon release. The 50 MRAD circle circumscribes pipper, providing a reference for locating pipper on HUD combining glass. The 25 MRAD circle circumscribes pipper, and provides a fixed range solution. Reticle does not have radar range or lag line display capabilities. Reticle is not displayed on instructor console center CRT HUD display page (figure 1-53).
31 (sh 4)	SRM seeker position or boresight cue	A constant-diameter circle that appears during A/A SRM mode and indicates which direction the simulated AIM-9 missile seeker head is pointed.



FIXED POSITION SYMBOLS

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Figure 1-145. HUD Symbology (Sheet 2)

Table 1-128. HUD Symbology (Continued)

Index No. (fig. 1-145)	Symbol	Description
22 (sh 2)	Gun cross	Appears during HUD unit boresighting in addition to gun cross (3, sheet 1) when BIT system selector (4, figure 1-77) is in HUD position and INITIATE switch (5, figure 77) is pressed. Gun cross aids in boresighting.
23 (sh 2)	Optimum angle of attack index	Appears at right side of angle of attack scale (25, sheet 2) with simulated landing gear down. Index is in fixed position and indicates simulated optimum angle of attack.
24 (sh 2)	Angle of attack pointer	Appears at right side of angle of attack scale (25, sheet 2) with simulated landing gear down. Index moves along scale and indicates simulated angle of attack.
25 (sh 2)	Angle of attack scale	Appears in left field of view to the right of airspeed scale (21, sheet 1) with simulated landing gear down. Scale is a vertical line marked in increments of 5 degrees. At each 10-degree mark, a two-character readout displays simulated angle of attack. Scale and readout are in fixed positions and increase in value from bottom to top.
26 (sh 3)	Air-to-air reticle	Appears during A/A gun and secondary modes. Reticle position varies over total field of view to indicate the computed prediction angle when RTCL switch (3, figure 1-94) is in AUTO or DSTB position. When RTCL switch is in CAGED position, reticle is in fixed position superimposed on gun cross (3, sheet 1). When simulated radar set is in boresight mode, reticle is in fixed position 2 degrees below gun cross. In fixed position, reticle does not indicate computed prediction angle. During A/A mode, reticle consists of a pipper, 50 milliradian (MRAD) circle, 25 MRAD circle, lag line, range scale, range bar, and range index.

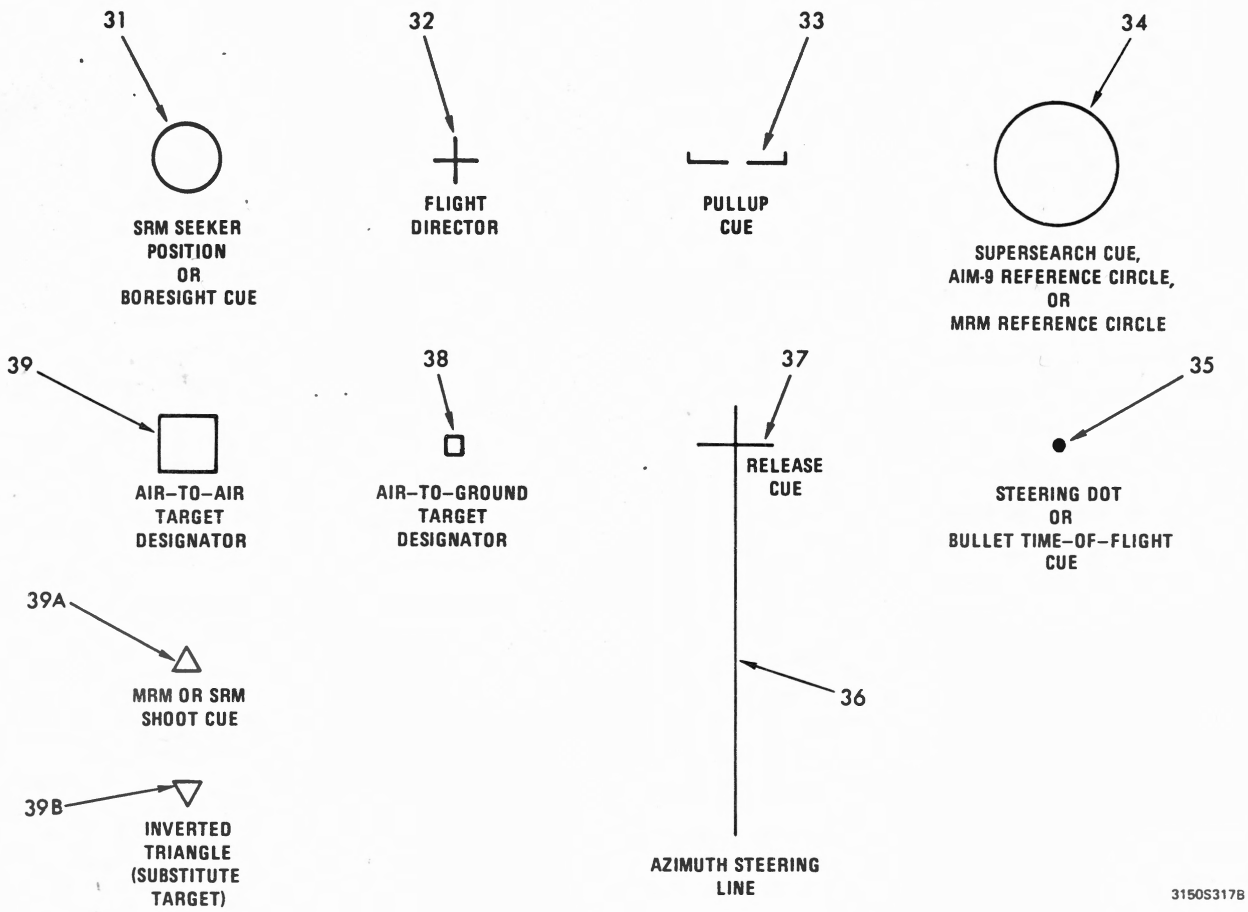

Figure 1-145. HUD Symbology (Sheet 4)

Table 1-128. HUD Symbology (Continued)

Index No. (fig. 1-145)	Symbol	Description
31 (cont) (sh 4)	SRM seeker position or boresight cue (cont)	Circle position varies over total field of view. Boresight cue replaces SRM seeker position in all A/A attack modes, except A/A gun mode, when boresight automatic acquisition mode is selected. In A/A gun mode, SRM seeker position is displayed and boresight cue replaces ASE circle (4, sheet 1).
32 (sh 4)	Flight director	Appears during ADI modes. Flight director position varies over total field of view to provide steering information. Flight director uses velocity vector (29, sheet 3) as a reference. If velocity vector is not present, director uses aircraft symbol (20, sheet 1) as a reference. Horizontal portion of flight director provides pitch steering information and vertical portion provides bank steering information.
33 (sh 4)	Pullup cue	Cue position varies vertically above or below velocity vector (29, sheet 3) and is roll stabilized. Cue appears below velocity vector (29, sheet 3) during A/G CDIP and A/G automatic modes. When symbol is coincident with or above velocity vector, symbol indicates immediate pullup must be performed to avoid simulated ground collision or simulated weapon blast.
34 (sh 4)	Supersearch cue, AIM-9 reference circle, or MRM reference circle	The supersearch cue is a fixed-diameter, 20-degree circle that appears centered on HUD optical center in all A/A attack modes when supersearch automatic acquisition mode is selected. Cue replaces ASE circle (4, sheet 1) normally displayed. The AIM-9 reference circle appears during A/A SRM mode in supersearch, boresight, or vertical scan automatic acquisition modes if the priority missile is caged. AIM-9 reference circle also appears during AIM-9L manual boresight mode instead of ASE circle (4, sheet 1) and steering dot (35, sheet 4).

Table 1-128. HUD Symbology (Continued)

Index No. (fig. 1-145)	Symbol	Description
34 (cont) (sh 4)	Supersearch cue, AIM-9 reference circle, or MRM reference circle (cont)	In manual boresight mode, circle flashes when radar antenna approaches AIM-9L gimbal limit. AIM-9 reference circle represents AIM-9 seeker field of view. The MRM reference circle is a fixed-diameter, 12-degree circle centered on aircraft symbol (20, sheet 1) that appears during A/A MRM search mode. Circle provides an immediate steering reference if an MRM must be launched without radar acquisition of the target.
35 (sh 4)	Steering dot or bullet time-of-flight cue	Appears during VI and A/A missile modes, except A/A SRM mode. Steering dot position varies over total field of view to aid in pointing simulated aircraft toward the simulated target so that missiles are aimed in the general vicinity of the target. During A/A missile modes, ASE circle (4, sheet 1) is used as a reference representing the envelope within which missile can be launched when in-range occurs. During the VI mode, steering dot is used to guide simulated aircraft behind and below target, using ASE circle as reference until visual contact is made. In A/A gun mode, bullet time-of-flight cue is displayed, representing gun firing range. Cue appears on outer edge of air-to-air reticle (26, sheet 3) during radar range track in disturbed reticle mode only. Gun firing range corresponds to 1.4 seconds time-of-flight or minimum bullet velocity of 500 feet per second, whichever produces the shortest range.
36 (sh 4)	Azimuth steering line	Appears during A/G automatic and A/G CDIP modes.

Table 1-128. HUD Symbology (Continued)

Index No. (fig. 1-145)	Symbol	Description
36 (cont) (sh 4)	Azimuth steering line (cont)	Steering line position varies over total field of view and is stabilized to remain perpendicular to the horizon. Steering line provides an azimuth steering reference with respect to velocity vector (29, sheet 3) and is used in conjunction with release cue (37, sheet 4). Simulated aircraft is maneuvered to place velocity vector over azimuth steering line to aid in directing aircraft toward target.
37 (sh 4)	Release cue	A short horizontal line that appears during A/G automatic and A/G CDIP modes and is roll stabilized to remain parallel to the horizon. Cue position varies along length of azimuth steering line (36, sheet 4) to provide in-range and release anticipation information.
38 (sh 4)	Air-to-ground target designator	A square symbol that appears during all A/G modes, except manual mode, and is roll stabilized to remain parallel to the horizon. Target designator position varies over total field of fiew. Target designator is positioned over simulated target or identification point (IP) by using TDC switch (8, figure 1-69). When TDC switch is released, target designator is then maintained over target or IP by simulated central computer to indicate line-of-sight to target. If target is outside HUD field of view, target designator flashes and remains on edge of combining glass to indicate target direction.
39 (sh 4)	Air-to-air target designator	A square symbol that appears during A/A missile, A/A gun, and VI modes. Target designator position varies over total field of view. Target designator is positioned over simulated target that simulated radar set is locked on to, indicating line-of-sight to target.

Table 1-128. HUD Symbology (Continued)

Index No. (fig. 1-145)	Symbol	Description
39 (cont) (sh 4)	Air-to-air target designator (cont)	If target is outside HUD field of view, target designator flashes and remains on edge of combining glass to indicate target direction. In A/A gun mode, target designator disappears when center of target designator comes within 25 mils of pipper on the A/A reticle (26, sheet 3) and range is less than 3000 feet. Target designator is replaced by inverted triangle (39B, sheet 4) to provide steering information. When target designator center is greater than 35 mils from pipper or range is equal to or greater than 3200 feet, inverted triangle disappears and target designator reappears.
39A (sh 4)	Shoot cue	Appears during A/A MRM or SRM modes when launch conditions exist for the mode selected. In MRM mode, shoot cue appears when weapon/mode switch (3, figure 1-69) on right throttle is in forward position; MASTER switch (6, figure 1-123) on ARMAMENT panel is in ARM position; radar is in high PRF final track; and target range is between R max 2 and R min. Shoot cue flashes when target range is between R max 1 and R max 2. In SRM mode, shoot cue appears when weapon mode switch is in center position; MASTER switch is in ARM position; radar is tracking a target; and radar range is between R max and R min. Shoot cue appears below air-to-air target designator (39, sheet 4). If target designator is positioned so close to lower edge of HUD 20 degree field-of-view that shoot cue will be cut off, shoot cue appears above air-to-air target designator. Shoot cue also appears above air-to-air target designator when target designator is below the horizontal center and close to left or right edge of HUD 20 degree field of view.

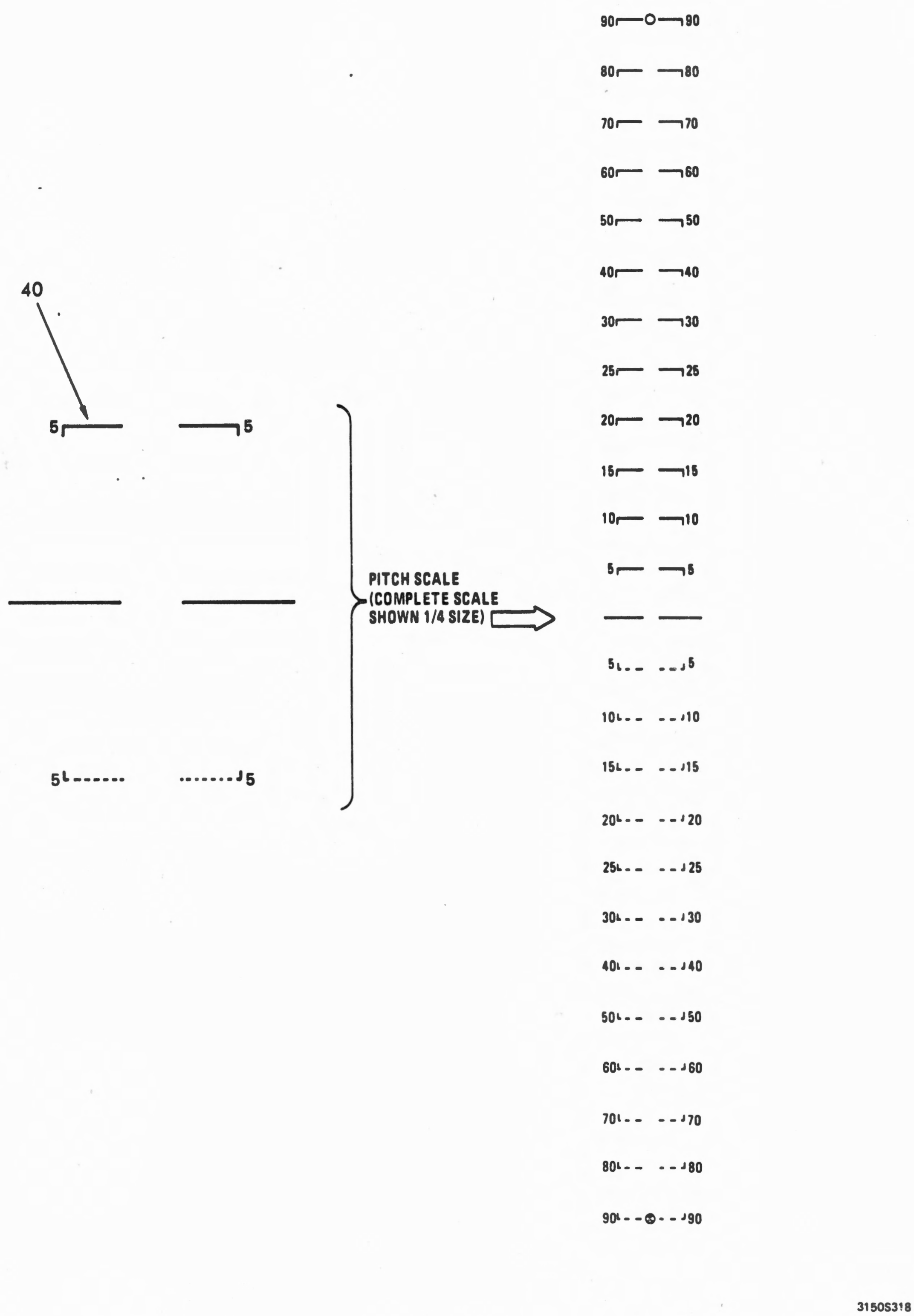

Figure 1-145. HUD Symbology (Sheet 5)

Table 1-128. HUD Symbology (Continued)

Index No. (fig. 1-145)	Symbol	Description
39B (sh 4)	Inverted triangle (substitute target)	Appears in A/A gun mode when air-to-air target designator (39, sheet 4) disappears due to movement of target designator center to within 25 mils of pipper on air-to-air reticle (26, sheet 3). Triangle provides HUD steering information to target. When air-to-air target designator reappears, inverted triangle disappears.
40 (sh 5)	Pitch scale	Appears during all modes and automatically appears if simulated central computer malfunctions and HUD set switches to secondary mode. Scale is normally centered about velocity vector (29, sheet 3) and displays pitch and roll information. Scale is roll stabilized to remain parallel to the horizon and varies position with velocity vector. Scale consists of a 0 degree pitch line superimposed on the horizon, and positive (solid) and negative (dashed) pitch lines. Scale is marked in increments of 5 degrees from 0 to ±30 degrees and in increments of 10 degrees from ±30 to ±90 degrees. Two-character readouts are repeated at opposite ends of each pitch line, except the zero pitch line. Readouts remain upright at roll angles less than 90 degrees. When 90 degree roll or pitch is exceeded, readouts are inverted. If the central computer receives invalid data for control of velocity vector, vector disappears and pitch scale is referenced to aircraft symbol (20, sheet 1). During secondary mode, pitch scale is referenced to aircraft symbol. At instructor console, pitch scale numbers are not roll stabilized and remain vertical at all times on center CRT HUD display page (figure 1-53). Pitch scale may also be displayed outside HUD display area on HUD display page until 0 degree line reaches edge of display area. Portion of scale outside display area will then disappear.

LIST OF ABBREVIATIONS AND SYMBOLS

A	ascending; ampere
A/A	air-to-air
AAA	anti-aircraft artillery
AAI	air-to-air identification
AAM	air-to-air missile
AAS	air-to-air search
AAT	air-to-air track
AB, A/B	afterburner
AC	alternating current
A/C	aircraft
ACC	acceleration
ACP	armament control panel
ACQ	acquisition
ACS	armament control set, armament control system
ACT	activate
A/D	air data
ADC	air data computer; analog-to-digital converter
ADDR	address
ADF	automatic direction finder; automatic direction finding
ADI	attitude director indicator
ADJ	adjust
ADV	advance
ADV PA	advance program address
AFCS	automatic flight control system
A/G	air-to-ground
AGM	air-to-ground missile
AGT	air-to-ground target
AHRS	attitude heading reference system
AI	analog input
AIC	air inlet controller
AIM	air intercept missile
ALN	align
ALT	altitude
ALT HLD	altitude hold
ALT HOLD	altitude hold
ALTMTR	altimeter
AMAD	airframe-mounted accessory drive
AMI	airspeed/Mach indicator
AMP	ampere
AN	alphanumeric
ANMI	air navigation multiple indicator
ANT SEL	antenna select
AOA	angle of attack
AOJ	angle of jam
APPR	approach
ARCP	air refueling contact point

ARI	aileron rudder interconnect
ASE	allowable steering error
ASKID	anti-skid
ASL	above sea level; azimuth steering line
ASSY	assembly
ATT HLD	attitude hold
ATT HOLD	attitude hold
AUR	aural (M&T test)
AUT	automatic
AUTO	automatic
AUX	auxiliary
AV BIT	avionics built-in test
AZ	aximuth
AZ SCAN	azimuth scan
BATH	best available true heading
BCN	beacon
BETA	yaw angle mnemonic
BINGO	return fuel state; return to this channel (radio)
BIT	built-in test
BKUP	backup
BLU	bomb live unit
BNG	bearing
BOOT ENA	bootstrap enable
BST PMP	boost pump
BST SYS MAL	booster system malfunction
BYP	bypass

C	center; centigrade; collision (path); common
CAI	closed loop analog input (M&T test); cockpit analog input
CAL	calibrate (M&T test)
CAS	control augmentation system; calibrated airspeed
CB	circuit breaker
CC	central computer; correct code
CCC	central computer complex; central computer control
CCW	counterclockwise
CDI	closed loop discrete input (M&T test); cockpit discrete input
CDIP	continuously displayed impact point
CFG	configuration
CG	center of gravity
CH	channel
CHA	change
CHAN	channel
CHAR	character
CHN	channel
CKT BKR	circuit breaker
CL	current limit
CLM	climb
CLR	clear
CLR OR	clear operand register
CNTR	counter

COMM	communication
COMP	composite; computer
CONF	configuration
CONFIG	configuration
CONF TANK	conformal tank
CONT LDG	control loading
CONTR	control
CP	control panel
CP LOCK	control panel lock
CPRSR	compressor
CPU	central processor unit
CR	carriage return (key)
CRT	cathode ray tube
CS	control switch
CTR	center; centerline tank
CW	clockwise
D	descending
DC	direct current
DEFL	deflection
DEG	degree, degrees
DEG/MIN	degrees per minute
DEG/RAD	degrees per radian
DEG/S	degrees per second
DEPR	depression
DEST	destination
DET	detection
DG	directional gyro; displacement gyro
DIL	displayed impact line
DISC	disconnect
DISENG	disengage
DME	distance measuring equipment
DOF	degree of freedom
DOS	disc operating system
DPLR	doppler
DPS	degrees per second
DRD	display readout device; data readout display
DRS	digital radar signal
DRSP	digital radar signal processor
DRU	digital readout unit
DRUIO	DRU I/O interrupt routine
DSC	digital scan converter
DSTB	disturb
ECCM	electronic countercounter-measures
ECM	electronic countermeasures
ECS	environmental control system
EEC	engine electronic control
EL	elevation
EL SCAN	elevation scan
ELV	elevation
EMER BST	emergency boost
EMERG	emergency
EMERG LG	emergency landing
EMERG TRANS	emergency transfer
EMI	electromagnetic interference
ENA	enable

ENG	engine
ENG HT	engine heat
ENT	enter
ENT IR	enter instruction register
ENT PA	enter program address
ENT REG	enter register
ENVIR	environment, environmental
EO	electro-optical
EOT	electro-optical target
EQPT	equipment
ET	emitter target
E-TIME	elasped time
EW	electronic warfare
E/W	east/west (display)
EWWS	electronic warfare warning system
EXCDNCE CNTR	exceedance counter
EXP	explain
EXPSR	exposure
EXT	extended; external
EXT LT	exterior lights
EXT PWR	external power
EXTST	external interrupts test (M&T test)
EXT TRANS	external transfer
EXU	execute
EXU IR	execute instruction register
F	Fahrenheit
FF	flip-flop (electronic storage device); free fall; fuel flow
FLAPS POS	flaps position
FLIGHT	master computer
FLITE	master computer
FLT	flight
FN	full scale negative (keyboard command)
FOV	field of view
FP	flight path; full scale positive (keyboard command)
FPH	flight path and scoring data
FPM	feet per minute
FPS	feet per second
FREQ	frequency
FT	foot, feet
FTIT	fan turbine inlet temperature
FT/MIN	feet per minute
FT/NMI	feet per nautical mile
FTS	feet per second
FT/S	feet per second
FWD	forward
G	guard; unit of acceleration of gravity
GAC	Goodyear Aerospace Corporation
GC	gyrocompass
GCA	ground control approach
GENL	general

GFI	ground fault interrupt
GMTI	ground moving target inhibit
GND PWR	ground power
GND RNG	ground range
GPM	gallons per minute
GS	ground speed
GSA	glideslope angle
GSD	glideslope deviation
HAC	aircraft altitude mnemonic
HDG	heading
HLT	halt
HLT/RUN	halt/run
HNG	hung (not released)
HOJ	home-on-jam
HPRF	high pulse repetition frequency
HRDS	hundreds
HSI	horizontal situation indicator
HT	heat
HUD	head-up display
HYB	hybrid
HYD	hydraulic; montion and control force M&T test
HYDR	hydraulic
HYS	hybrid search
HZ	hertz
IAS	indicated airspeed
IBS	interference blanker set
IC	integrated circuit; internal controller
ICC	integrated communications control (panel)
ICS	intercommunication system; internal countermeasures sets (TEWS application)
ID	identification, identifier
IFF	identification friend or foe
ILS	instrument landing system
IMU	inertial measuring unit
INH	inhibit
INI	initial, initialization
INIT	initial, initialization
INIT POS SET	initial position set
INOP	inoperative
INS	inertial navigation system
INST	instruments
INT	intensity; internal; interrupt; external interrupts (M&T test)
INTCP	intercept
INTCP LCRZ	intercept localizer
INTER	interrupt
INTEROG	interrogate
INT GEN	interrupt generator
INTLK	interlock
INTRG	interrogate
I/O	input/output
IOS	instructor operator station

IP	identification point; instructor pilot
I/P	identification of position
IR	infrared; instruction register
IX	mass moment of inertia about XB axis mnemonic
IXZ	product of inertia about the XB-ZB axis mnemonic
IY	mass moment of inertia about YB axis mnemonic
IZ	mass moment of inertia about ZB axis mnemonic
JETT	jettison
JFS	jet fuel starter
KCAS	knots calibrated airspeed
KHZ	kilohertz
KN	knot, knots
KN/S	knots per second
KT	knot
KTAS	knots true airspeed
KTS	knots
KV	kilovolt
KYBD	keyboard
L	left
LAT	latitude
LAT/BNG	latitude/bearing
LATPPT	aircraft latitude mnemonic
LBS	pounds
LCG	lead-computing gyroscope
LDG	landing
LDG GR	landing gear
LED	light-emitting diode
LG	landing gear
L/MSL	left missile
LON	longitude
LONG	longitude
LONPPT	aircraft longitude mnemonic
LRS	long-range search
LRU	line replaceable unit
LT	light
M1	mode 1
M2	mode 2
M3/A	mode 3A
M/4	mode 4
MA	master; milliampere
MAD	magnetic azimuth detector
MAG VAR	magnetic variation
MAL	malfunction
MALF	malfunction
MAN	manual
MASS	aircraft mass mnemonic
MAX	maximum
MC	mode C; mode controller
MCL	master clear
MCP	maintenance control panel
MFO	mainframe option

MHZ	megahertz
MIC	microphone
MIL	military; milliradian
MIN	minute, minutes; minimum
MIN AB	minimum afterburner
MINV	inverse of aircraft mass mnemonic
MISC	miscellaneous
MK	mark, a designation preceding model numbers
MOD	moderate
MPRF	medium pulse repetition frequency
MRAD	milliradian
MRM	medium-range missile
MSEC	millisecond
MSL	missile
MSTR	master
MSTR CLR	master clear (switch)
M&T	maintenance and test
MTP	multiple
M/V	magnetic variation
NAV	navigation
NCI	navigation control indicator
NEG REF	negative reference
NM	nautical mile, miles
NMI	nautical miles
NON PSP	non-programmable signal processor
NORM	normal
NOZ POS	nozzle position
N/S	north/south (display)
N/T	nose/tail
NWS	nosewheel steering
OFLY FRZ	overfly freeze
OPR	operate
OR	operand register
ORIDE	override
O/S	offset
OXY	oxygen
PA	program address
PC	power control
PC1, PC2	power control hydraulic system
PCT	percent
PDOT	roll acceleration mnemonic
PE	parity error
PE INH	parity error inhibit
PH	program halt
PH A	phase A
PH B	phase B
PH C	phase C
PH ENA	program halt enable
PHI	roll angle mnemonic
PI	priority interrupt
PK	probability of kill
PLA	power lever angle
POS	position
PP	present position

PPH	pounds per hour
PPI	plan position indicator
P/R	pitch ratio
PRC	pitch ratio changer
PRCA	pitch/roll channel assembly
PRF	pulse repetition frequency
PROB	problem
PROG	program
PROG REST	program restrict
PRU	pressure up (keyboard command)
PSDOT	heading change rate mnemonic
PSI	pound-force per square inch; aircraft heading angle mnemonic
PSIG	pound-force per square inch gage
PSIO	parallel-to-serial I/O
PSP	programmable signal processor
PT	paper tape; point
P-TIME	problem time
PTP	paper tape punch
PTR	paper tape reader
PWR	power
PXA	roll rate mnemonic
QDOT	pitch acceleration mnemonic
QTY	quantity
QYA	pitch rate mnemonic
R	right
RAD	TACAN (tactical air navigation) radial; radian, radians
RAD OFF	radiate off
RAD ON	radiate on
RAD/S	radians per second
RAM	raid assessment mode; random access memory
RC	resistor capacitor
RCALL	recall
RDOT	yaw acceleration mnemonic
RDP	radar data processor
RDR	radar
RDY	readiness check (M&T procedure)
REC	receive
REF DES	reference designator
REG	register
REST	restrict
RET	retracted
RF	radio frequency
R/MSL	right missile
RNG	range, ranging
ROL	roll angle
RP	ripple
RPM	revolutions per minute; rounds per minute
RRC	roll ratio changer
RSET	reset
R/T	receiver/transmitter

RTCL	reticle
RUD	rudder
RUD PED ADJ	rudder pedal adjust
RWR	radar warning receiver
RWY	runway
RZA	yaw rate mnemonic
SAU	scientific arithmetic unit
SEC	second
SEL	select
SEL O/S	select offset
SH	sheet; shoulder
SIL	silence
S INT	set interval
SL1	slave 1
SL2	slave 2
SPD	speed; calibrated airspeed
SPD BK	speed brake
SRM	short-range missile
SRS	short-range search
SS	supersearch
S-S	sequentially scored, sequential-scoring
STA	station
STA/JETT	station jettison
STBY	standby
SW	switch; sidewinder (AIM-9, SRM)
S-WAY	slipway
SYM	symbol
SYNC	synchronous
T	tail chase (path); time
T1	slave 1 computer
T2	slave 2 computer
TAC	TACAN (tactical air navigation)
TAC#1	slave 1 computer
TAC#2	slave 2 computer
TACAN	tactical air navigation
TACAN CHAN	tactical air navigation channel
TACAN DME	tactical air navigation distance measuring equipment
TACAN STA	tactical air navigation station
TACTICS#1	slave 1 computer
TACTICS#2	slave 2 computer
TAS	true airspeed
TCN	TACAN (tactical air navigation)
TDC	target designator control
TEMP	temperature
TEWS	tactical electronic warfare system
TGT	target
THETA	pitch angle mnemonic
THRU	through
T O	takeoff

T/O	takeoff
TOL	tolerance
T/O RWY	takeoff runway
TOT	total
TOTAL INT	total internal
T/R	transmitter/receiver
TRIG	trigger
TRK	track
TTY	teletypewriter
TWS	TEWS (tactical electronic warfare system)
TYP	typical
UHF	ultra high frequency
UNARMD	unarmed
UNLKD	unlocked
UTL	utility; utility hydraulic system
V	volt
VA	voltage adjustment
VAC	volts alternating current
VDC	volts direct current
VHF	very high frequency
VI	visual identification
VIM	visual identification mode
VIS	visual
V_{max}	maximum speed
VOL	volume
V/P	voltage to pressure
VRMS	volt root mean square
VS	velocity search
VSD	vertical situation display
VSI	vertical speed indicator
VTRUE	true airspeed mnemonic
WGHT	weight
WO	without
WPNS	weapons
WT	weight
XBAR	distance between aircraft mass center and body axis origin along XB axis mnemonic
XFMR	transformer
XFR	transfer
XMT	transmit
XMTR	transmitter
YBAR	distance between aircraft mass center and body axis origin along YB axis mnemonic
ZBAR	distance between aircraft mass center and body axis origin along ZB axis mnemonic
ZR	zero (keyboard command)
^{o}/min	degrees per minute

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Table 1-127. Canopy-Mounted Controls and Indicators

Index No. (fig. 1-144)	Control/Indicator	Function
1	Canopy grips	Used to manually lift canopy open.
2	Air refueling READY indicator light 2A1A10DS1	Comes on when simulated air refueling slipway doors are open to indicate the system is ready for boom engagement. At instructor console center control panel, READY light on REFUEL-READY switch/ indicator (41, figure 1-11) comes on. When REFUEL-READY switch/indicator is pressed and released, cockpit ready light goes off, READY light goes off, and REFUEL light comes on during simulated aerial refueling. If EMERG A/R handle (figure 1-76) is used, READY light stays on throughout aerial refueling.
3	Mirrors	Rear view mirrors provided for convenience of pilot.
4	Standby magnetic compass indicator 2A1A10A1	Continuously indicates simulated aircraft magnetic heading. Compass is marked in increments of 5 degrees from 0 to 360 degrees. At each 30 degree mark, the number displayed multiplied by 10 corresponds to the angle. Cardinal headings are marked as N, E, S, and W.
5	Internal canopy manual unlock handle	Unlocks canopy if CANOPY CONTROL (figure 1-133) is inoperative. Removing quick-release pin from handle and pulling handle up and aft unlocks canopy if CANOPY CONTROL is in UP position. Canopy can then be manually forced aft and up with canopy grips (1).
6	Lock/shoot indicator lights 2A1A10DS2, DS3	Come on steady to indicate radar is tracking a target. Lights flash to indicate that shoot cue (39A, figure 1-145, sheet 4) is displayed on the HUD, and target is in range of selected armament.

1-41. COCKPIT DISPLAYS.

1-42. GENERAL. The display units in the cockpit consist of the head-up display (HUD), the air navigation multiple indicator (ANMI) display, and the tactical electronic warfare system (TEWS) display. The HUD displays steering and simulated aircraft status information and projects it into the pilot's field of view. The ANMI displays radar tracking of targets for identification and/or attack. The TEWS display provides information on the detection and type of threat to the simulated aircraft.

1-45. Typical Displays in the A/A Mode. The A/A mode is the basic attack mode of the simulated aircraft and is automatically activated when the other modes are not activated. In the A/A mode, the HUD symbols display steering, weapon, and simulated aircraft data for medium range missile (MRM), short range missile (SRM), and gun attacks against airborne targets.

1-46. Figure 1-146 shows a composite of all symbols which can be displayed in the A/A mode. Figure 1-147 shows typical displays used for MRM steering. Figures 1-148 and 1-149 show typical SRM steering displays. Figure 1-150 shows typical gun mode steering displays. In each figure, the track displays are shown with aircraft scales rejected by placing SYM switch (2, figure 1-94) on HUD control panel in the REJ position. Rejecting the scales highlights attack information. Figure 1-151 shows typical displays in automatic acquisition modes. For more details on automatic acquisition modes, refer to paragraph 1-59. Symbols are also shown in figure 1-145 and described in table 1-128. For more details on A/A mode displays, refer to T.O. 1F-15A-2-24 and T.O. 1F-15A-34-1-1.

1-47. Typical displays in the AIM-9L manual boresight mode are shown in figure 1-149, sheet 2. This mode enables the pilot to manually boresight an AIM-9L at one target while the radar is tracking another target at which an AIM-7F missile has been launched. This mode is selected by placing weapon/mode switch (3, figure 1-69) on right throttle grip at SRM position and then depressing and holding IFF interrogate switch (7, figure 1-69). The simulated aircraft must then be maneuvered to place SRM seeker position circle (31, figure 1-145, sheet 4) inside ASE circle (4, figure 1-145, sheet 1) on the HUD. When the AIM-9L missile is launched at the second target, AIMVAL appears at the instructor console on the TEWS and INTERCEPT display pages (figures 1-56 and 1-55) on the right CRT. Both ET's are then scored.

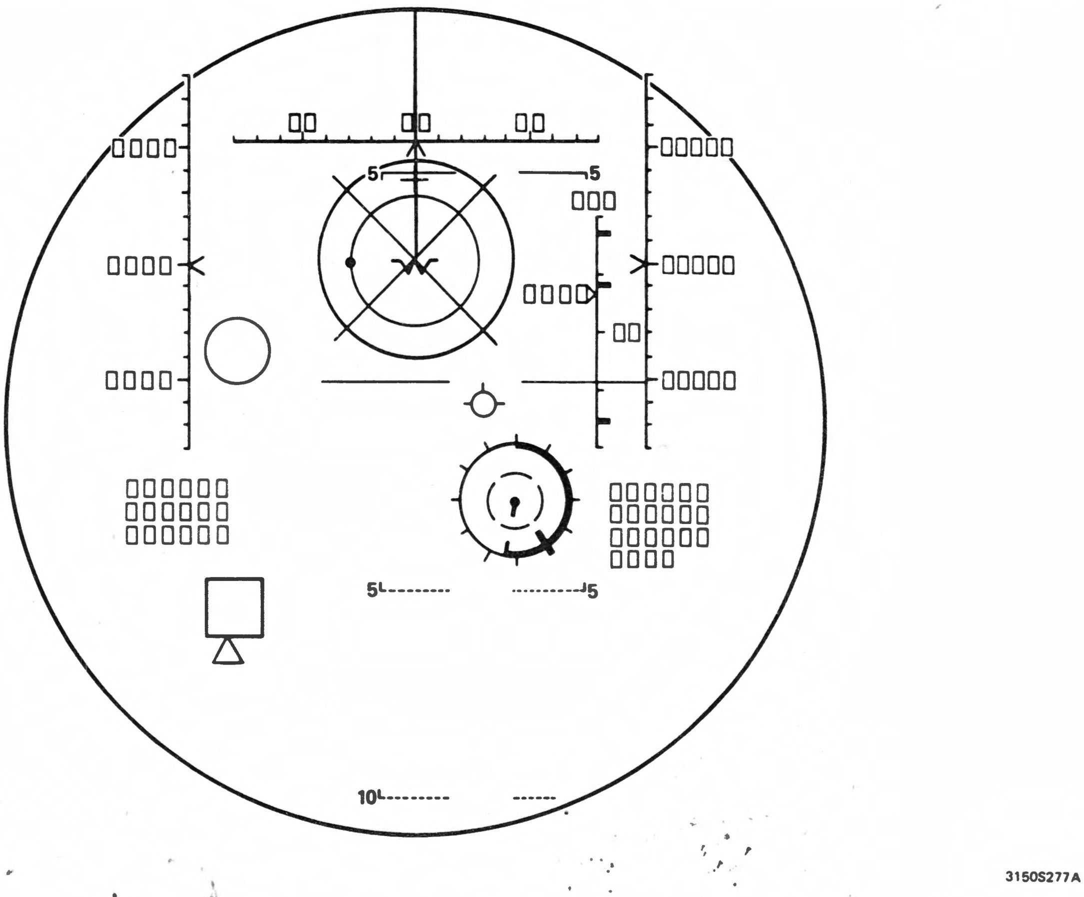


Figure 1-146. A/A Mode Symbols

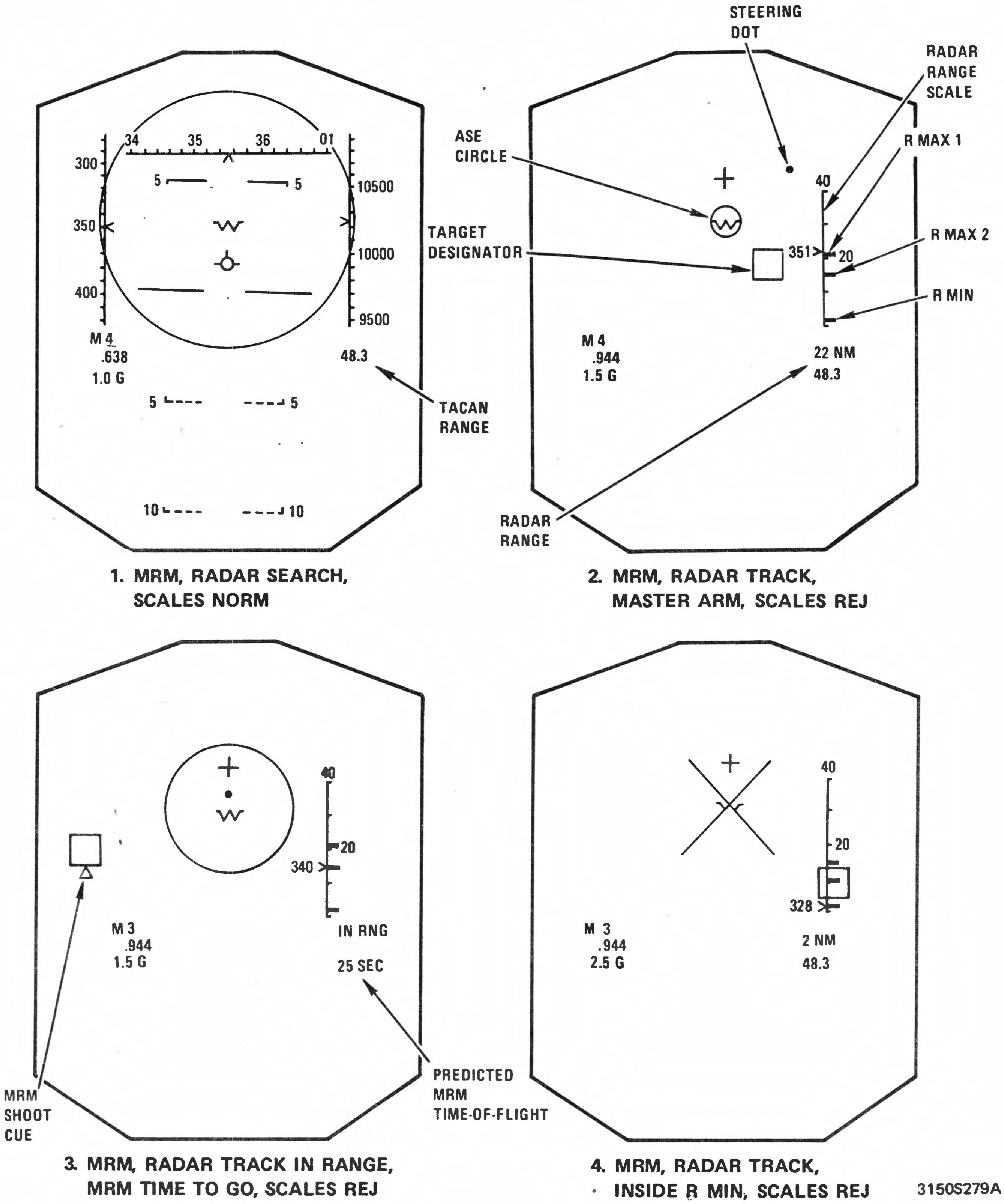


Figure 1-147. MRM Steering Displays

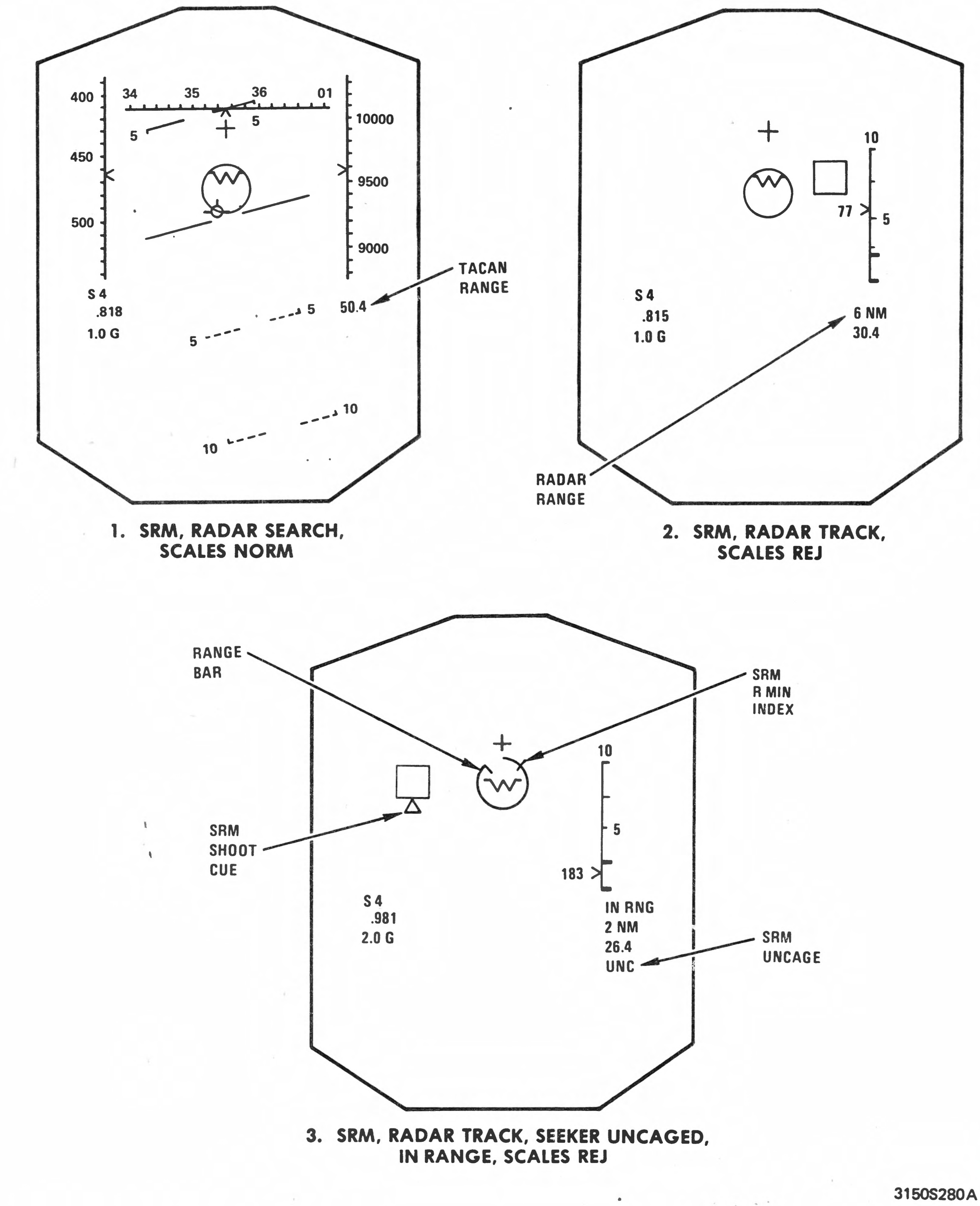


Figure 1-148. SRM Steering Displays (AIM-9J)

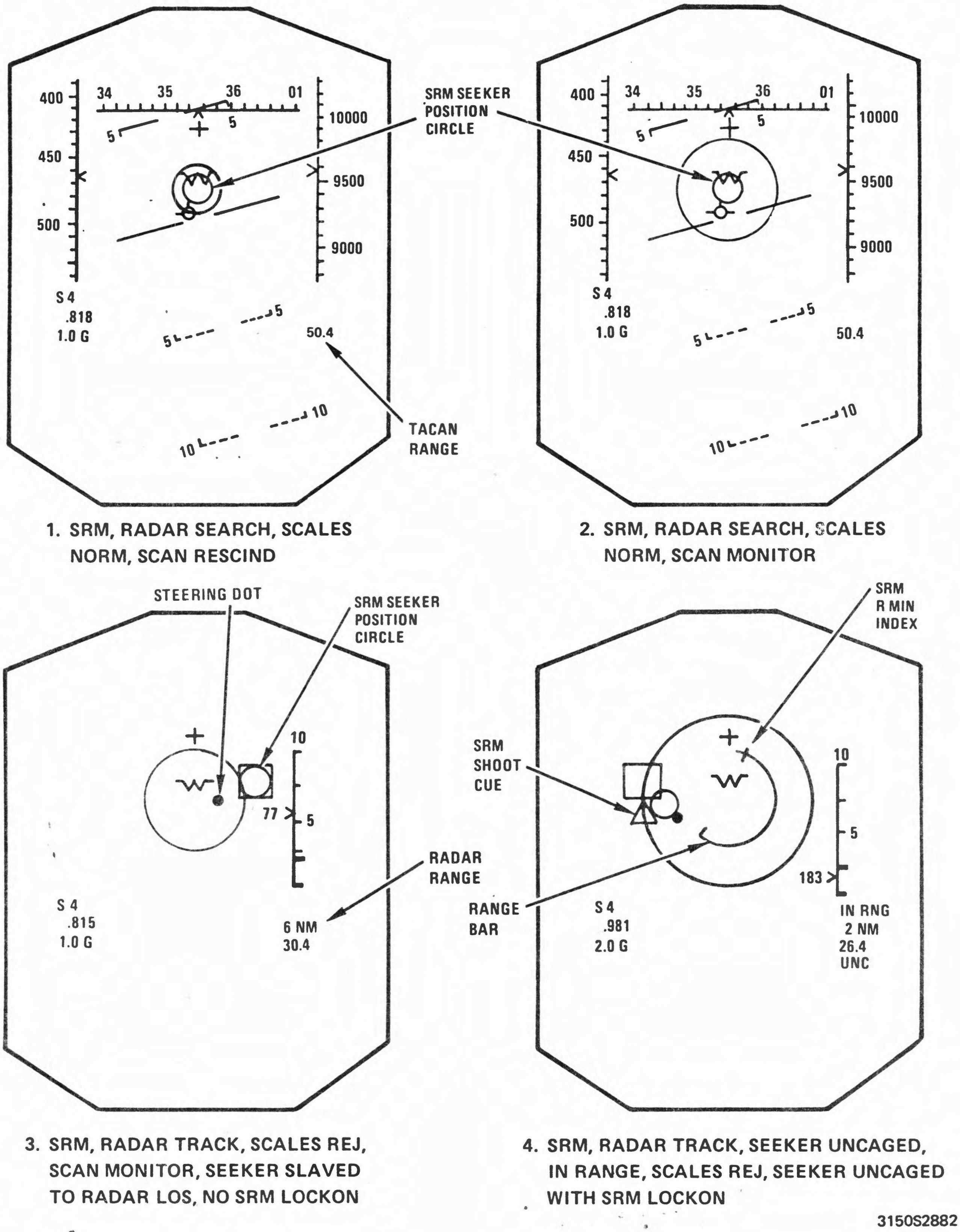
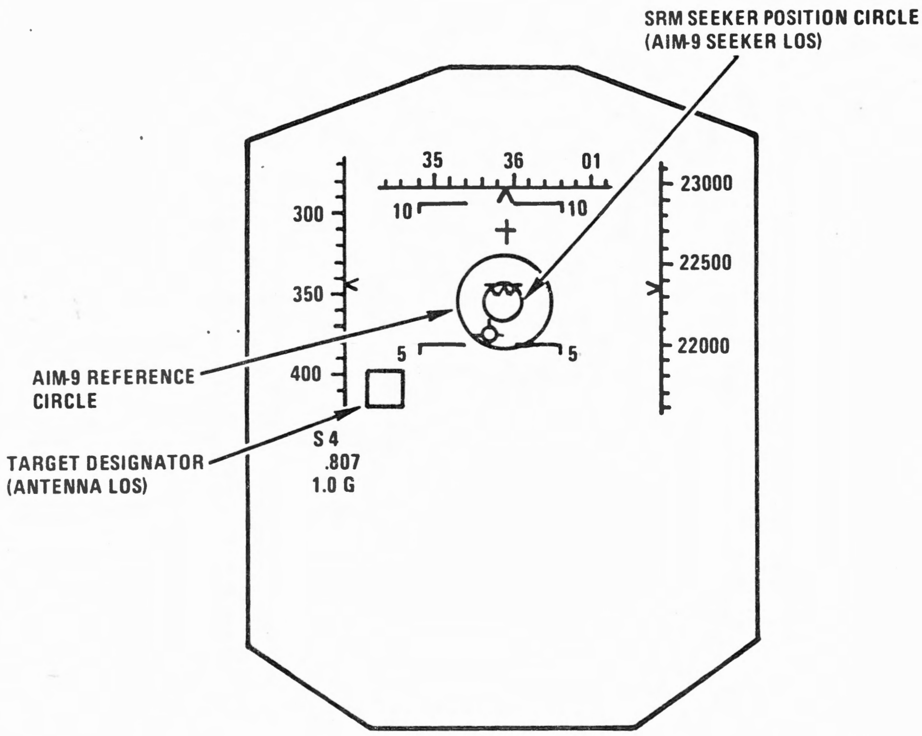


Figure 1-149. SRM Steering Displays (AIM-9L) (Sheet 1 of 2)



5. AIM-9L MANUAL BORESIGHT DISPLAY, RADAR TRACK, SCALES NORM, SCAN MONITOR, IFF BUTTON DEPRESSED, SEEKER CAGED, NO SRM LOCKON

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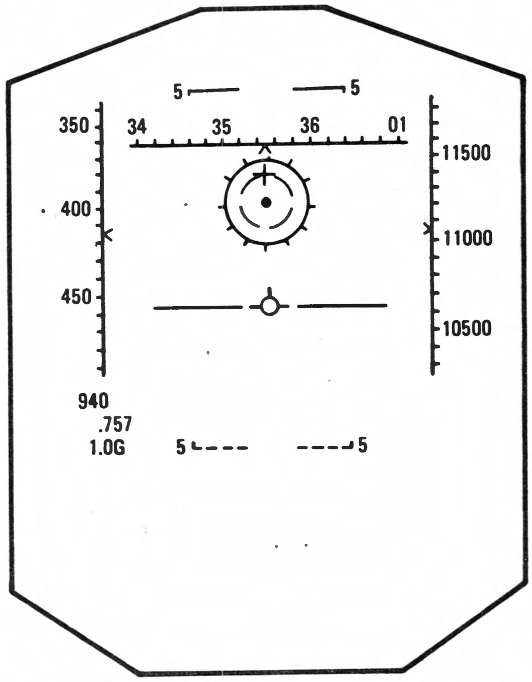
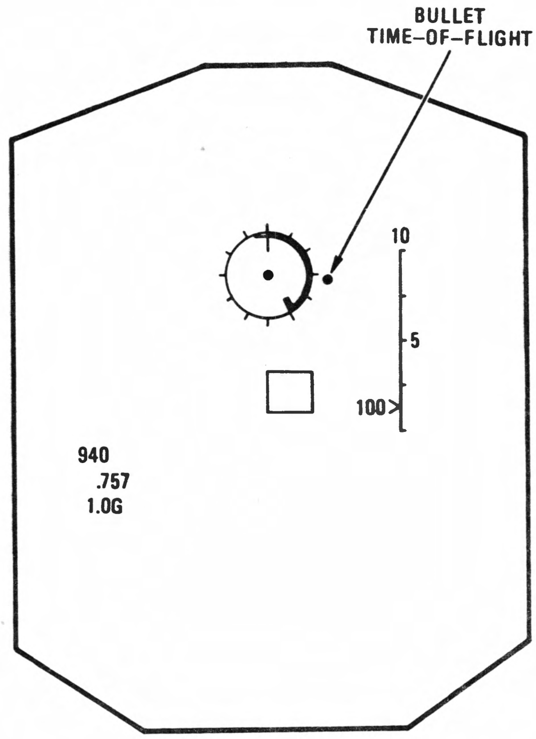
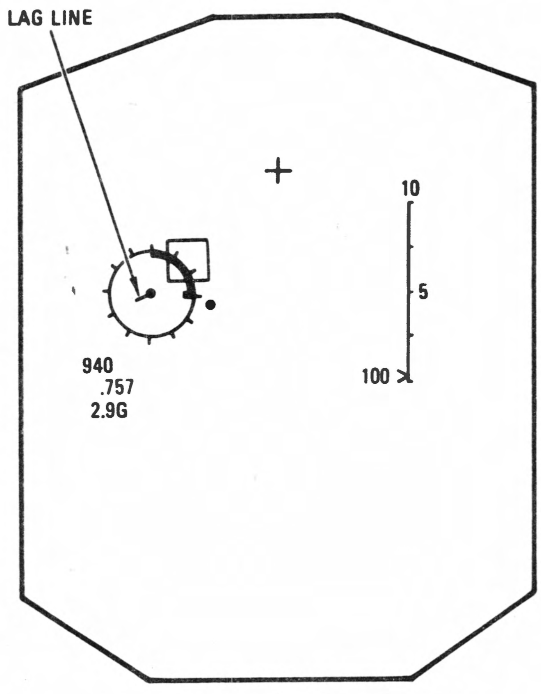
Figure 1-149. SRM Steering Displays (AIM-9L) (Sheet 2)



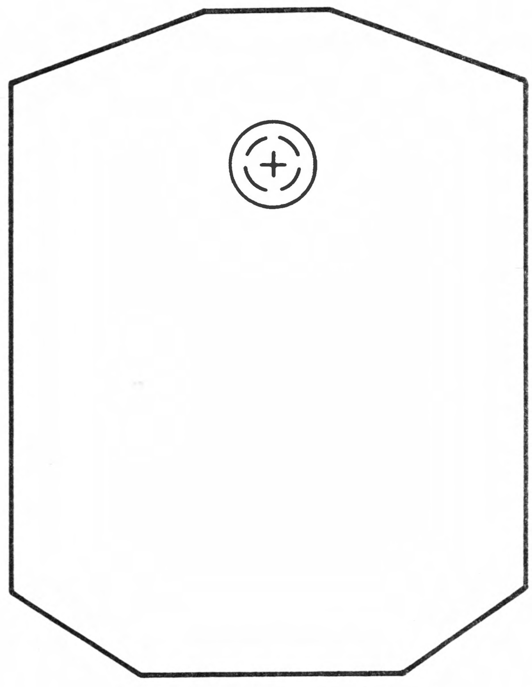
1. A/A GUN MODE, RADAR SEARCH, SCALES NORM



2. A/A GUN MODE, RADAR TRACK, SCALES REJ



3. A/A GUN MODE, RADAR TRACK, SCALES REJ



4. STANDBY RETICLE

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Figure 1-150. Gun Mode Steering Displays

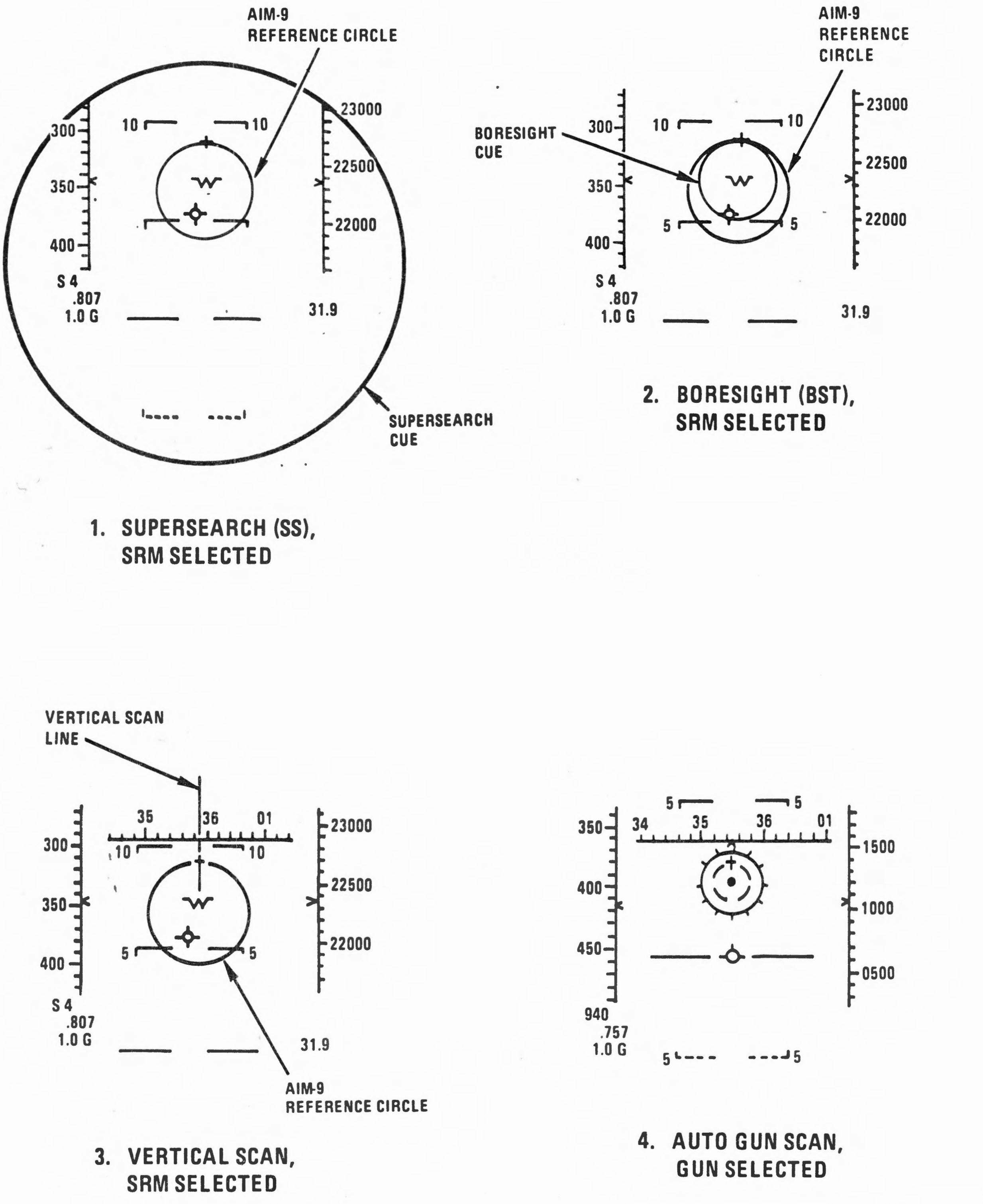

Figure 1-151. Automatic Acquisition Mode Displays

1-48. Typical Displays in the VI Mode. In the VI mode, the HUD symbols display data necessary to steer the simulated aircraft to the vicinity of the simulated target for visual identification prior to activation of the A/A mode.

1-49. Figure 1-152 shows a composite of all symbols which can be displayed in the VI mode. Figure 1-153 shows typical displays used for visual identification steering. The track displays are shown with aircraft scales rejected by placing SYM switch (2, figure 1-94) on HUD control panel in the REJ position. Rejecting the scales highlights the attack information. Symbols are also shown in figure 1-145 and described in table 1-128. For more details on VI mode displays, refer to T.O. 1F-15A-2-24 and T.O. 1F-15A-34-1-1.

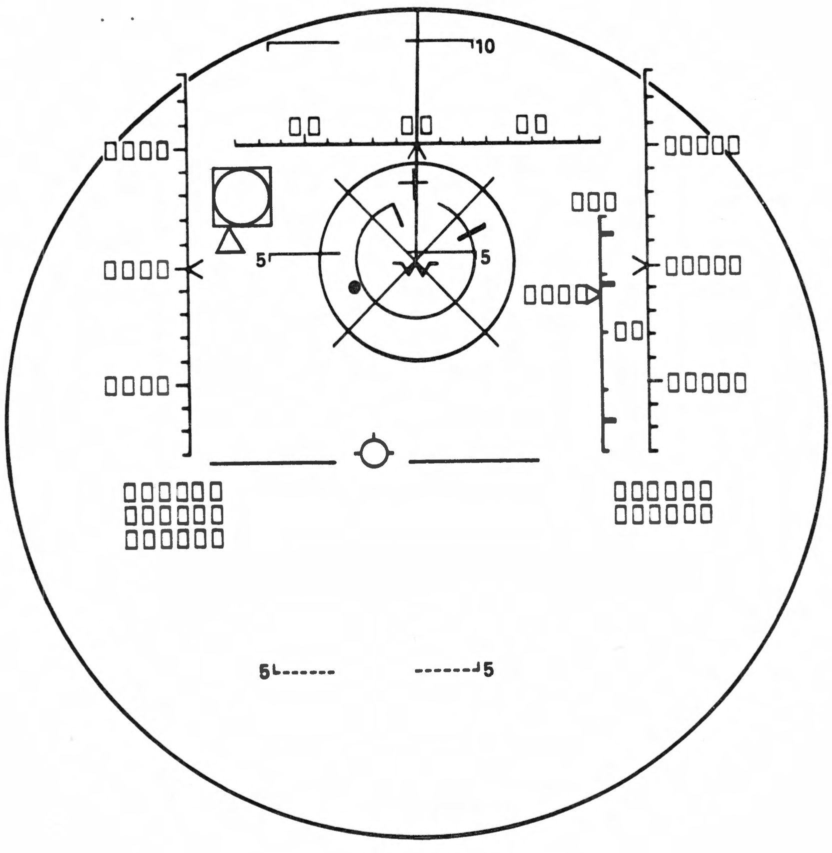

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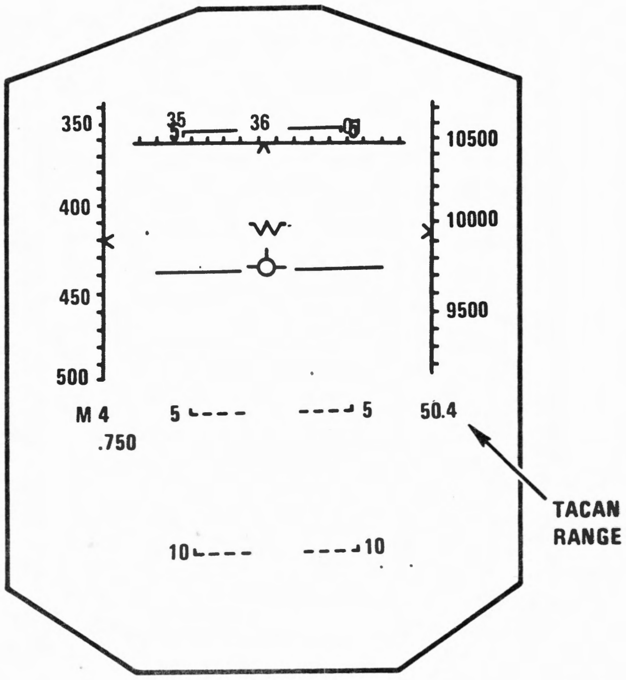
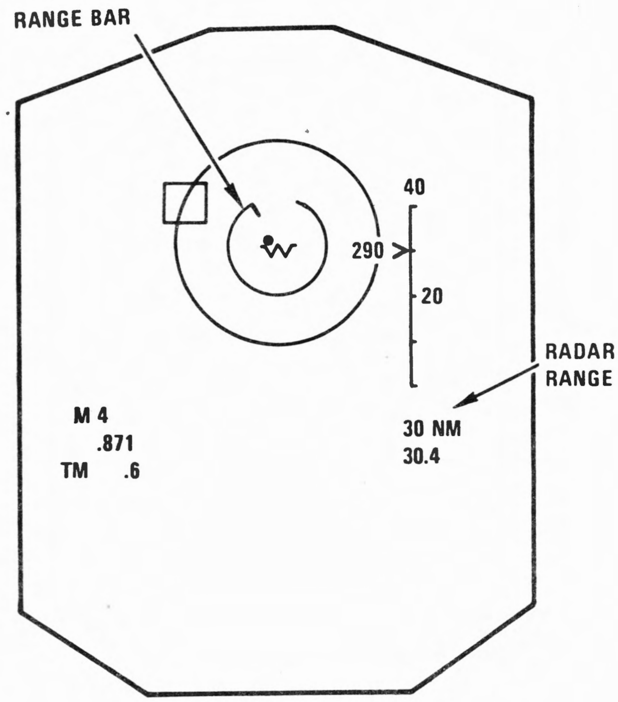
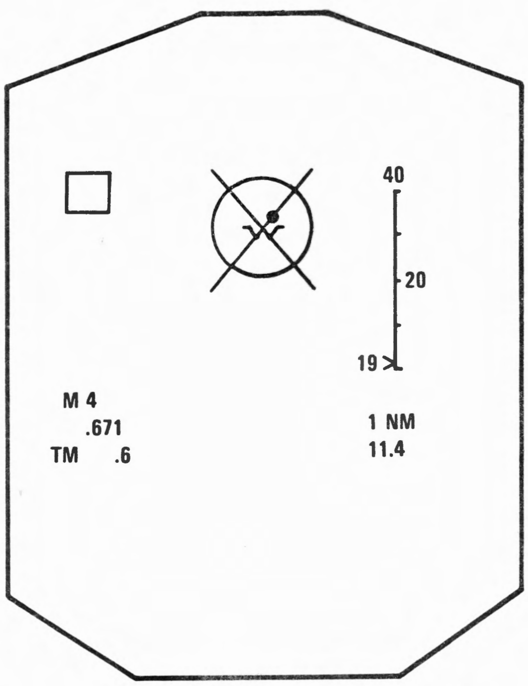
Figure 1-152. VI Mode Symbols



1. VI MODE, MRM, RADAR SEARCH, SCALES NORM



2. VI MODE, MRM, RADAR TRACK, SCALES REJ



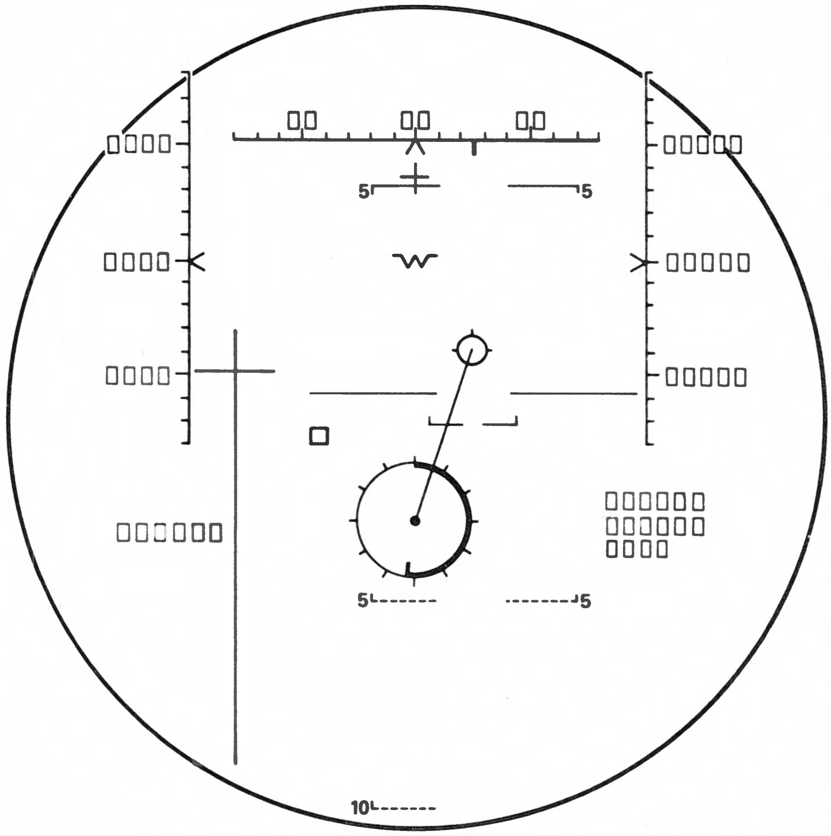
3. VI MODE, MRM, BREAK X RANGE SCALES REJ

3150S283A

Figure 1-153. Visual Identification Steering Displays

1-50. Typical Displays in the A/G Mode. The A/G mode enables attack of ground targets. In the A/G mode, the HUD symbols display steering, weapon, and simulated aircraft data for gun and bomb attacks against ground targets.

1-51. Figure 1-154 shows a composite of all symbols which can be displayed in A/G mode. Figure 1-155 shows typical displays used for auto mode steering. Figure 1-156 shows typical displays used for CDIP mode steering. Figure 1-157 shows typical displays used in a manual weapons delivery. Figure 1-158 shows typical displays used in a direct weapons delivery. Figure 1-159 shows typical displays used in a CDIP weapons delivery. Figure 1-160 shows typical displays used in an auto weapons delivery. Figure 1-161 shows displays used in an EO weapons delivery. Symbols are also shown in figure 1-145 and described in table 1-128. For more details on A/G displays refer to T.O. 1F-15A-2-24 and T.O. 1F-15A-34-1-2.



3150S264

Figure 1-154. A/G Mode Symbols

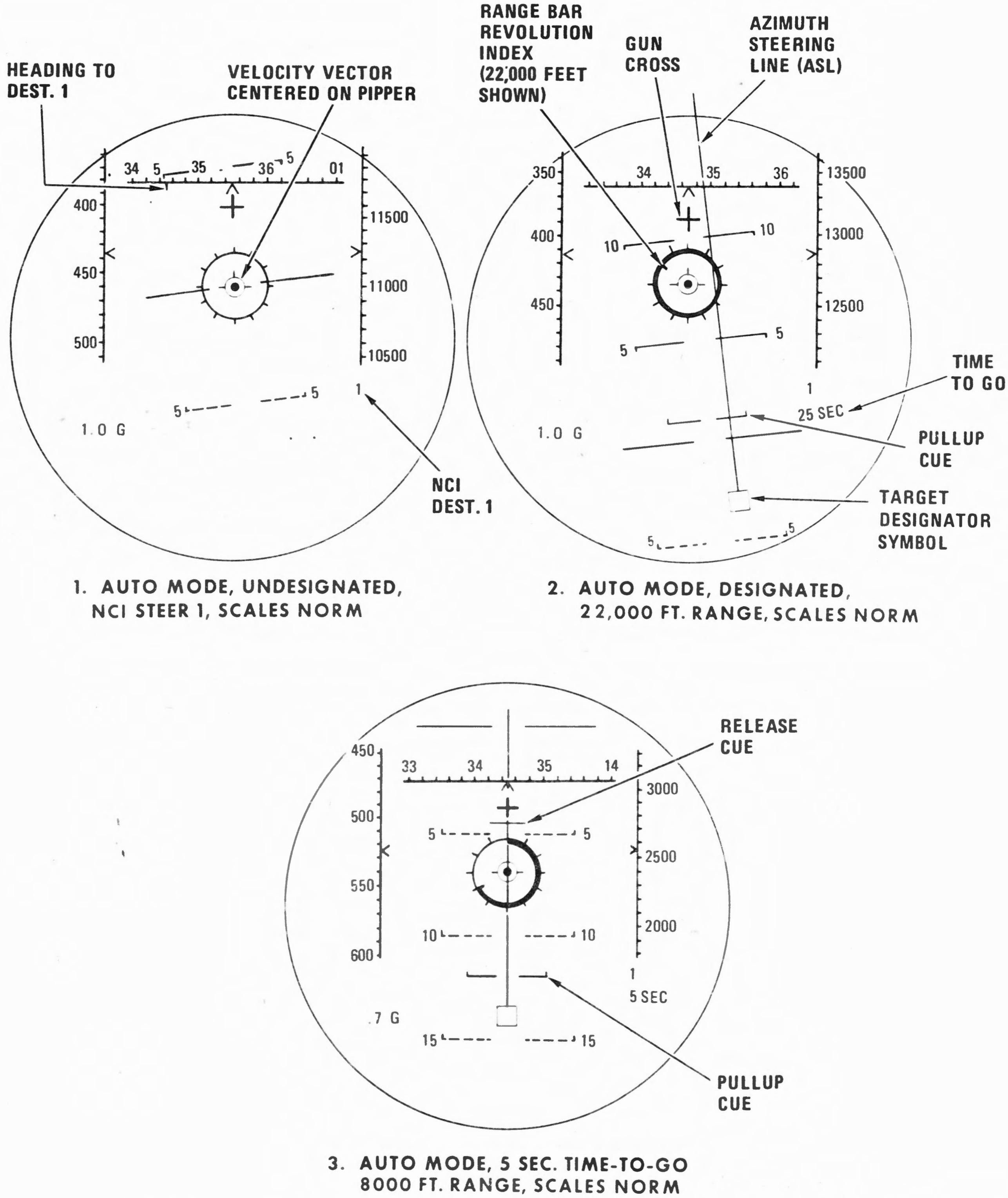
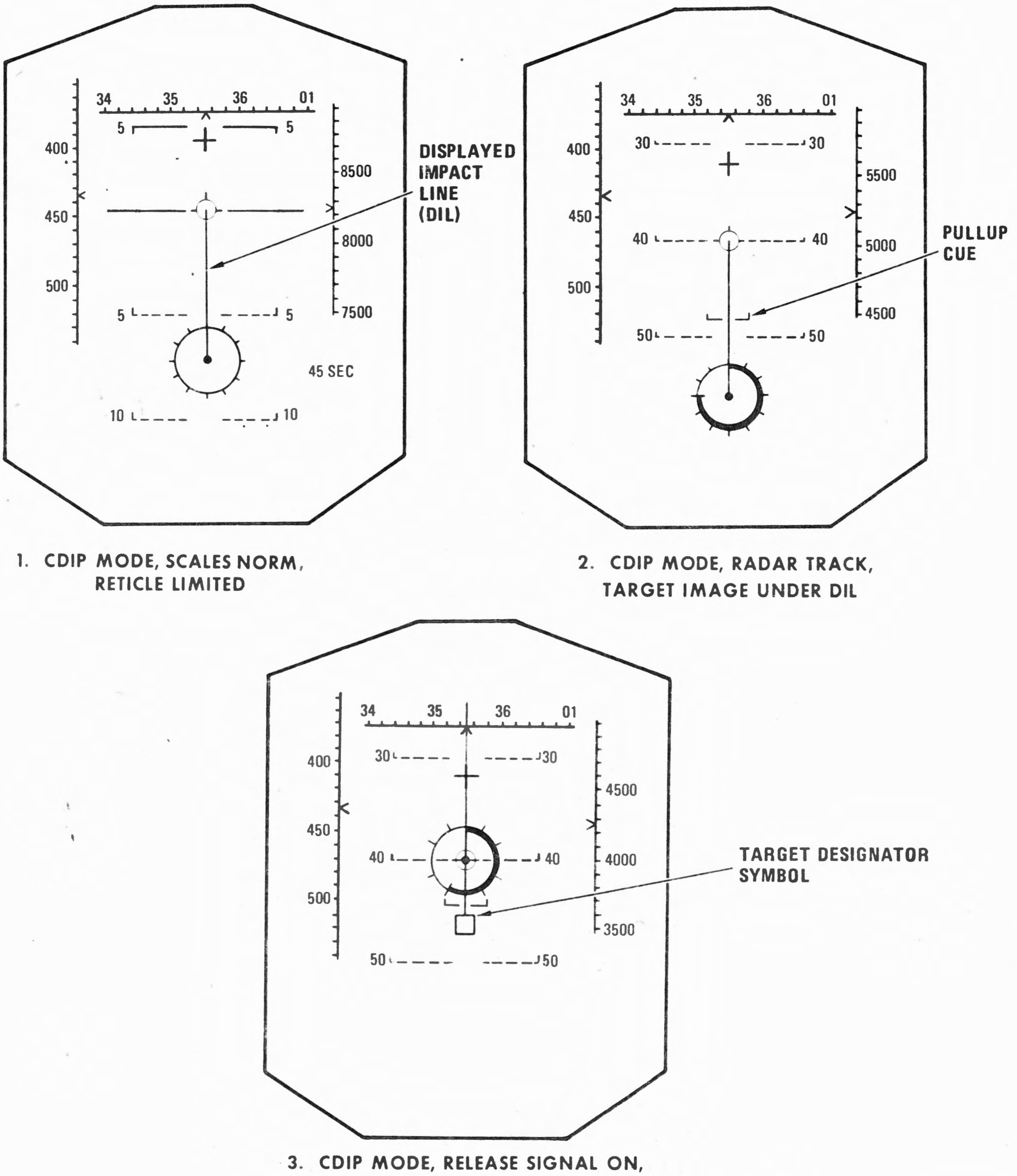


Figure 1-155. Auto Mode Steering Displays



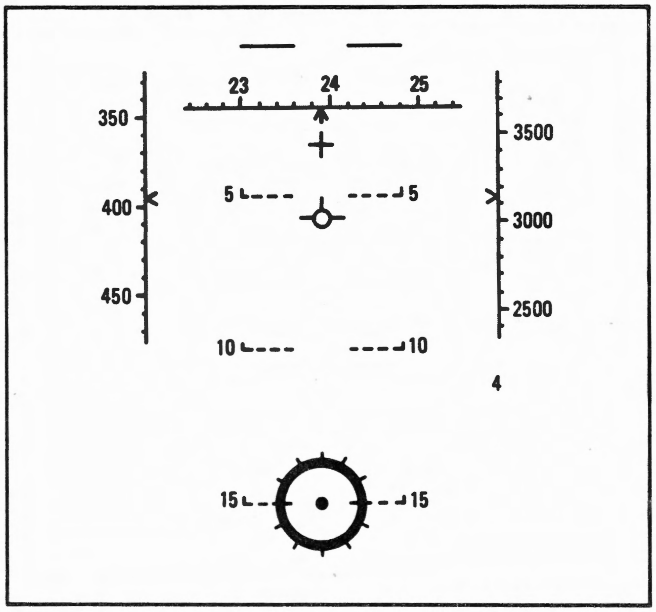
1. CDIP MODE, SCALES NORM, RETICLE LIMITED

2. CDIP MODE, RADAR TRACK, TARGET IMAGE UNDER DIL

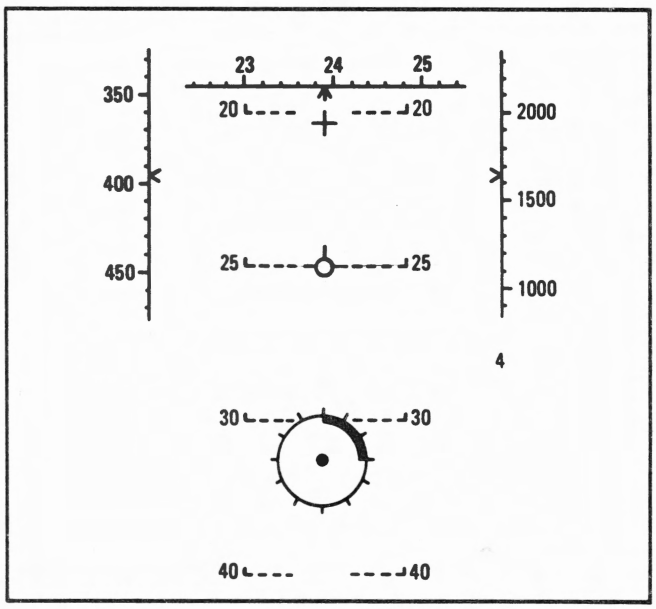
3. CDIP MODE, RELEASE SIGNAL ON, TARGET DESIGNATOR TRACKS TARGET

Figure 1-156. CDIP Mode Steering Displays

MANUAL
MODE SELECTED



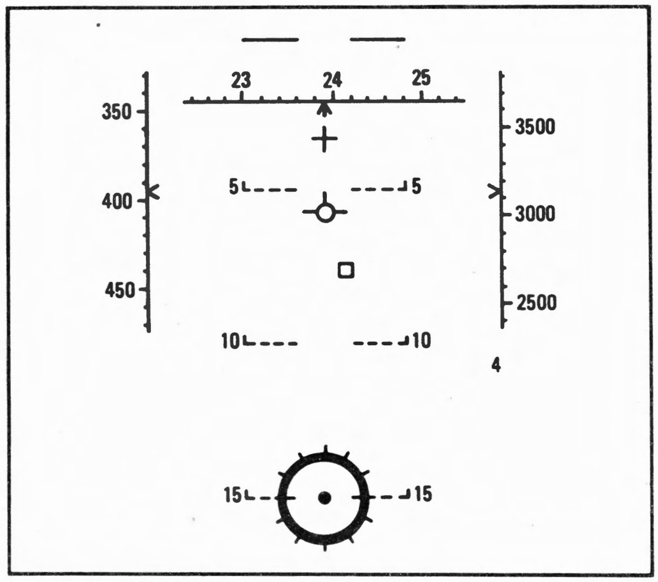
RADAR PROVIDES
SLANT RANGE



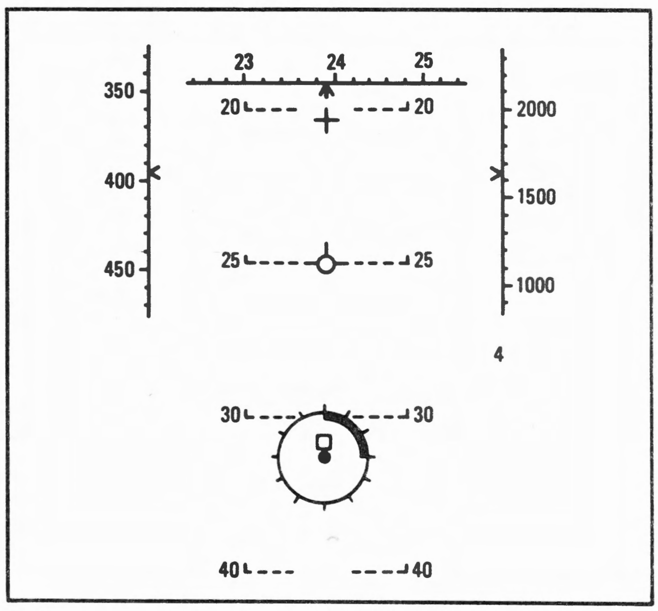
3150S287

Figure 1-157. Manual Delivery Displays

DIRECT MODE/
PROGRAM SELECTED



RADAR PROVIDES
SLANT RANGE



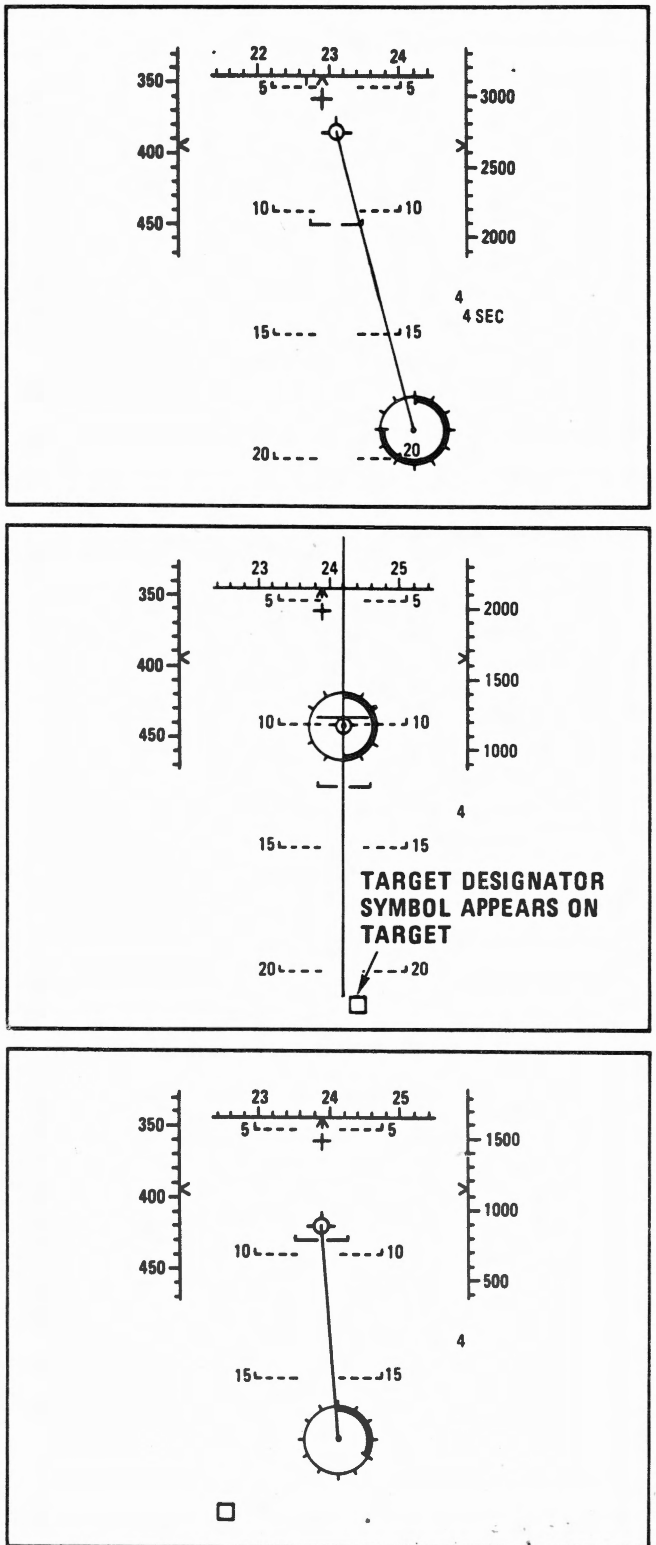
3150S288

Figure 1-158. Direct Delivery Displays

CDIP SELECTED

WEAPON RELEASE BUTTON DEPRESSED

WEAPON RELEASE BUTTON RELEASED



3150S289

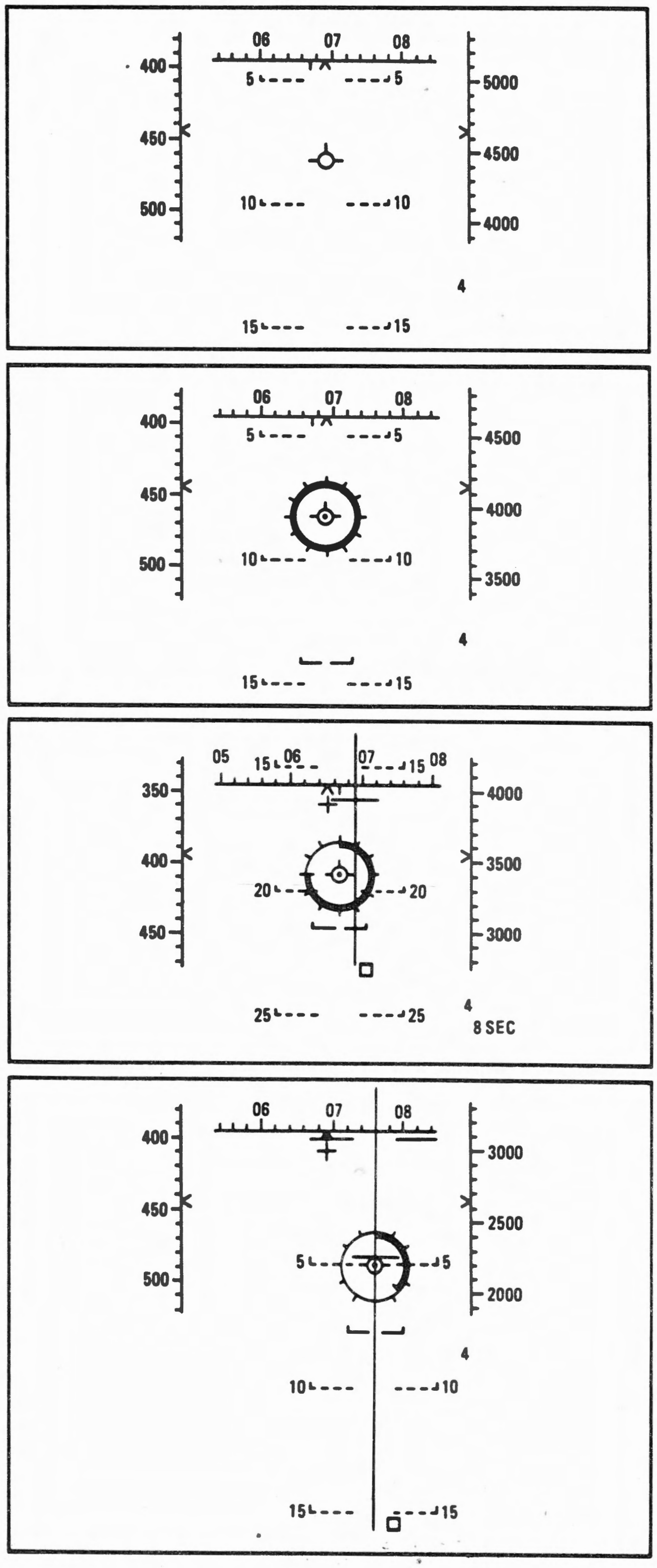
Figure 1-159. CDIP Delivery Displays

A/G SELECTED, WITH NO DELIVERY MODE SELECTED

AUTOMATIC MODE SELECTED (TARGET UNDESIGNATED)

TARGET DESIGNATION, ACQUISITION AND TRACKING

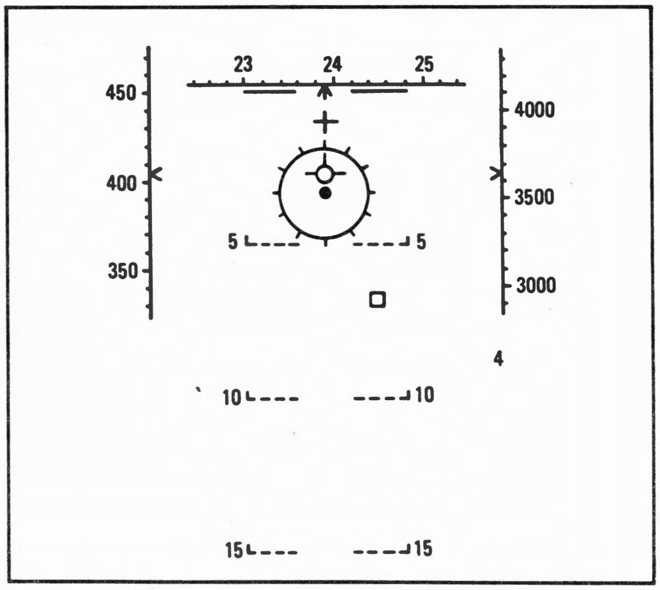
STEERING AND WEAPON RELEASE



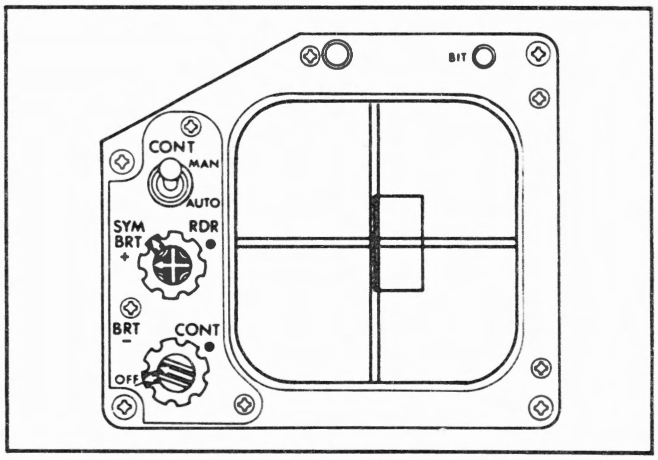
3159S290

Figure 1-160. Auto Delivery Displays

EO DELIVERY
SELECTED



LOCKON
AND RELEASE



3150S302

Figure 1-161. EO Delivery Displays

1-52. Typical Displays in the ADI Mode. The ADI mode is the simulated aircraft navigation steering mode. In the ADI mode, the HUD symbols display navigation data for takeoff, cruise, and landing operations. Figure 1-162 shows a composite of all symbols which can be displayed in ADI mode. Figure 1-163 shows typical displays used for TACAN and NAV steering. Figure 1-164 shows typical displays for ILS/NAV and ILS/TACAN steering. Symbols are also shown in figure 1-145 and described in table 1-128. For more details on ADI mode displays, refer to T.O. 1F-15A-2-24.

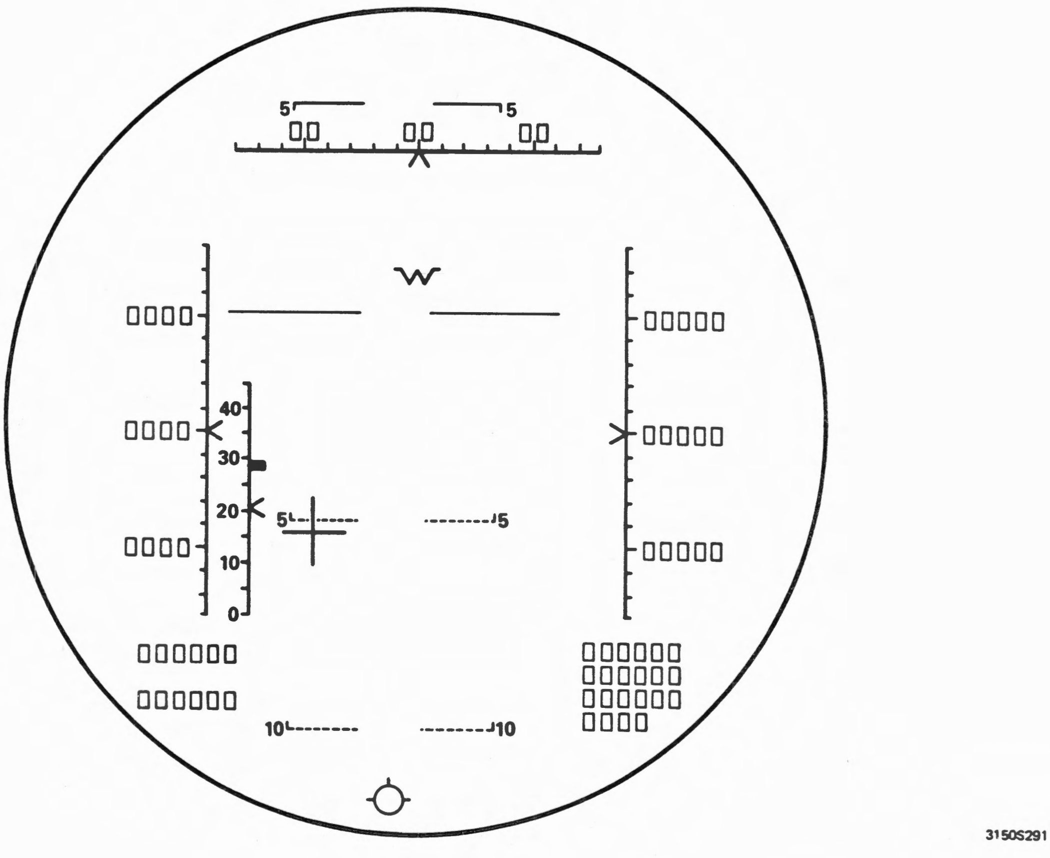


Figure 1-162. ADI Mode Symbols

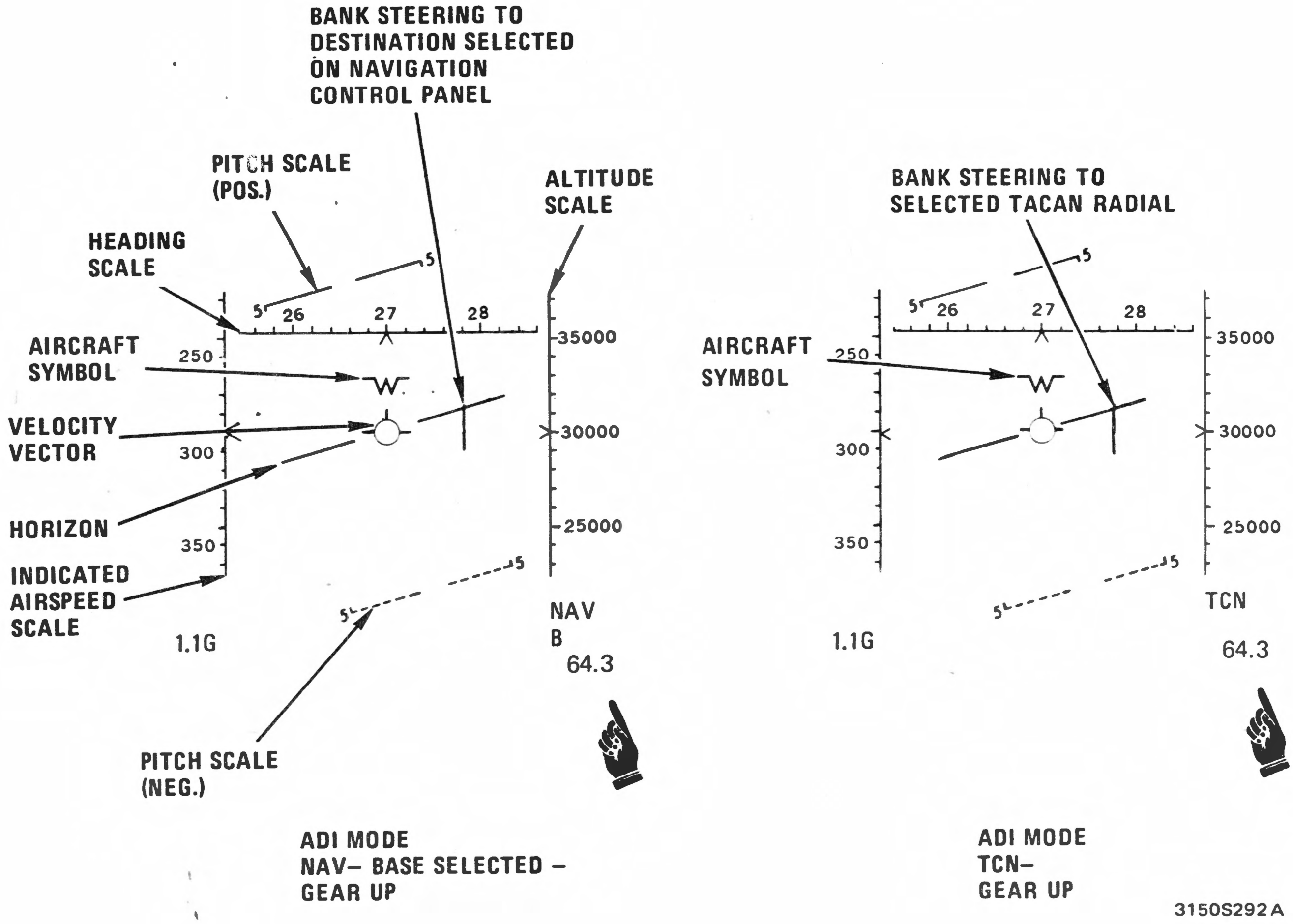


Figure 1-163. TACAN/NAV Mode Displays

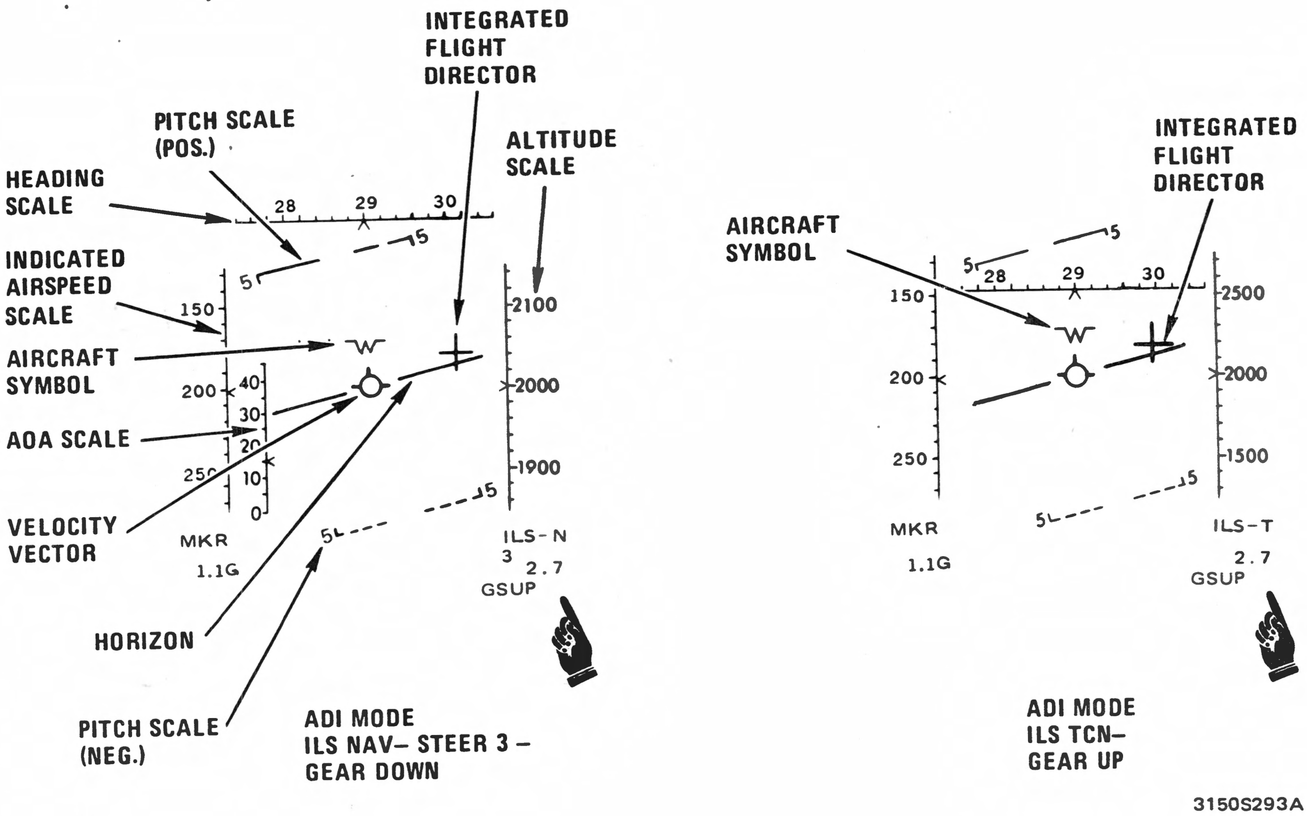
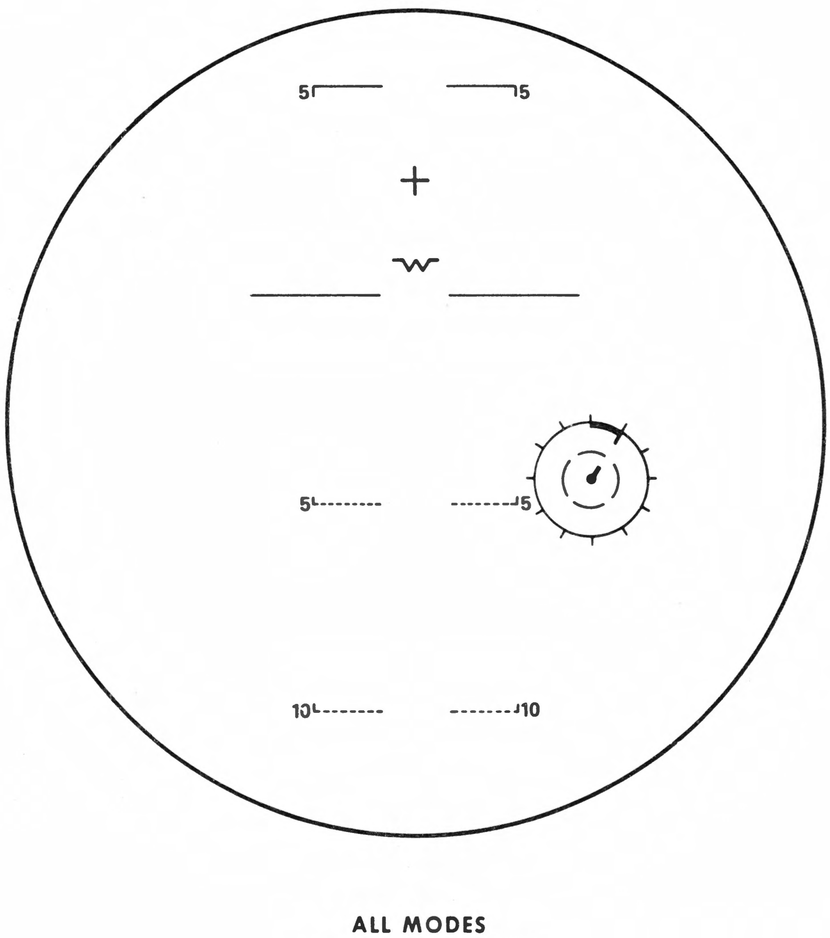


Figure 1-164. ILS/NAV and ILS/TACAN Mode Displays

1-53. Typical Display in the Secondary Mode. If the simulated central computer is inoperative, the HUD automatically switches to a secondary mode and presents symbols associated with the A/A gun mode (see figure 1-165). This occurs independently of the actual mode selected. Symbols are also shown in figure 1-145 and described in table 1-128.

1-54. HUD Titler Data Display. When selected, HUD displays date, mission number, aircraft number, squadron number, pilot code, and flight number as entered in simulated central computer on the NCI panel (figure 1-140). No other symbols and windows are displayed. Figure 1-166 shows a typical display. HUD titler data displays are described in index no. 12 through 16, table 1-128. For more details on HUD titler data, refer to T.O. 1F-15A-34-1-1.

1-55. All displays on the cockpit HUD, with the exception of the standby reticle, also appear on the instructor console center CRT HUD display page (figure 1-53). For more details on HUD modes and HUD operation, refer to T.O. 1F-15A-2-24, T.O. 1F-15A-34-1-1, and T.O. 1F-15A-34-1-2.



ALL MODES
(HUD SET IN SECONDARY MODE
DUE TO CENTRAL COMPUTER NO/GO)

3150S294A

Figure 1-165. Secondary Mode Display

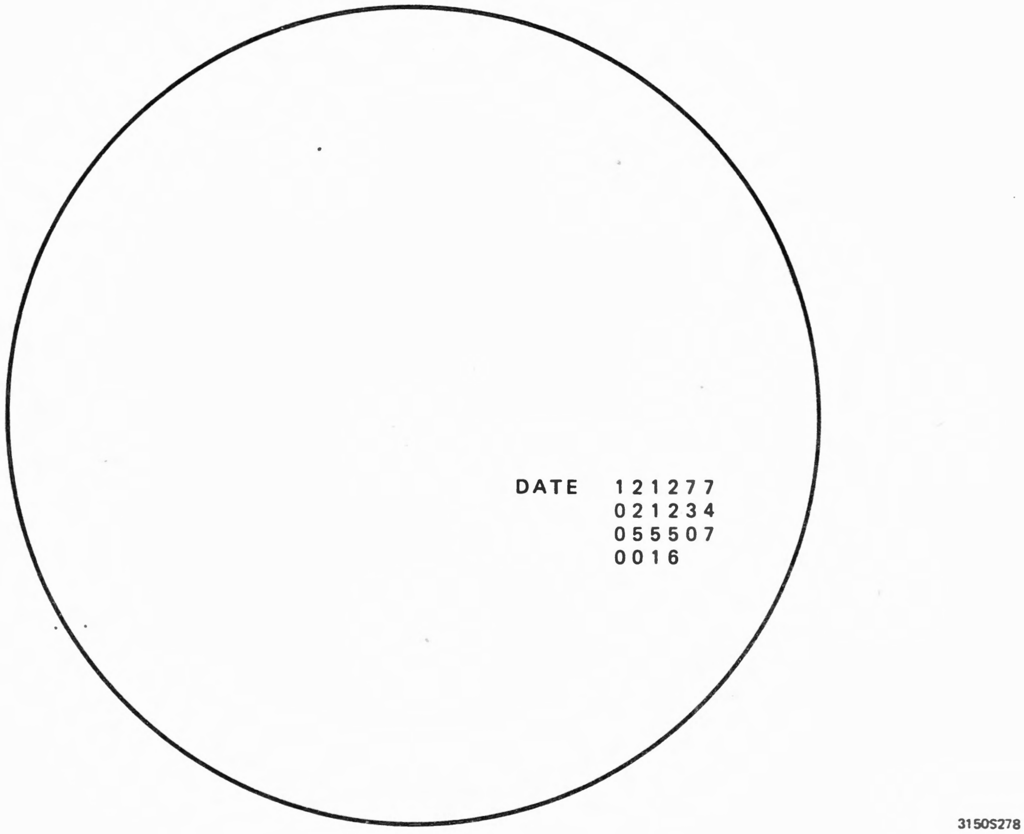
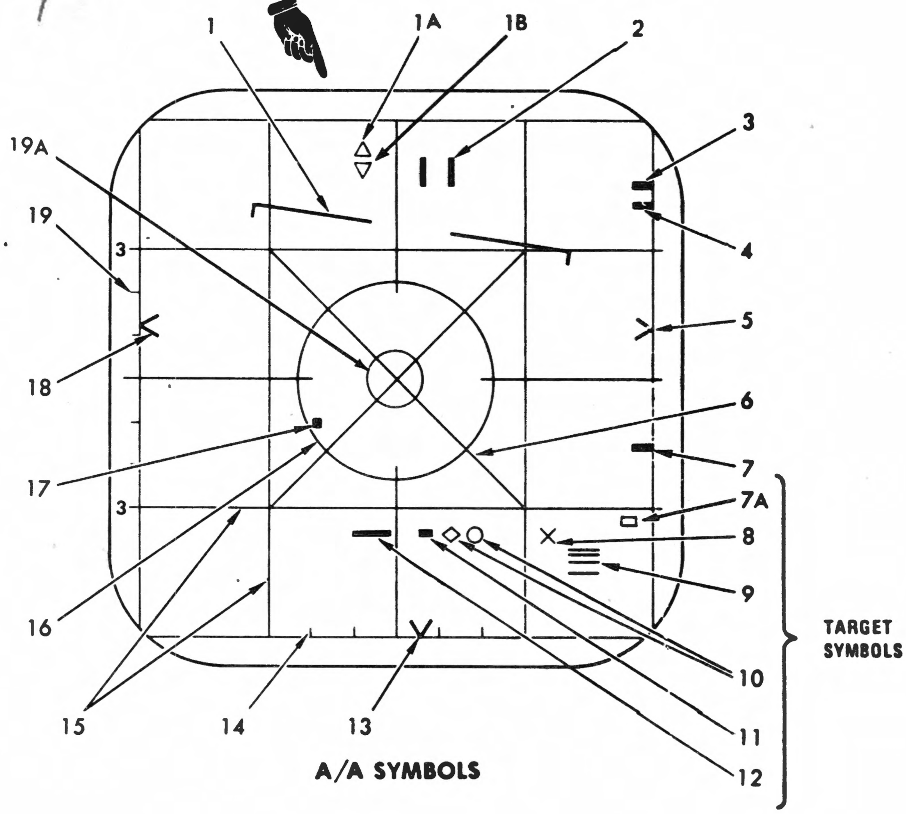


Figure 1-166. HUD Titler Data Display

1-56. AIR NAVIGATION MULTIPLE INDICATOR DISPLAY. The ANMI presents situation displays for all radar modes. The mode and type of display available are a function of the simulated aircraft operating mode (A/A, VI, A/G), the munitions selected, and the simulated radar set operating mode.

1-57. The symbols and windows which can be displayed on the ANMI are shown in figure 1-167 and described in table 1-129. The operating modes and displays available are described in paragraphs 1-58 through 1-86. The symbols and windows displayed on the cockpit ANMI are also displayed on the instructor console left CRT ANMI display page (figure 1-52).



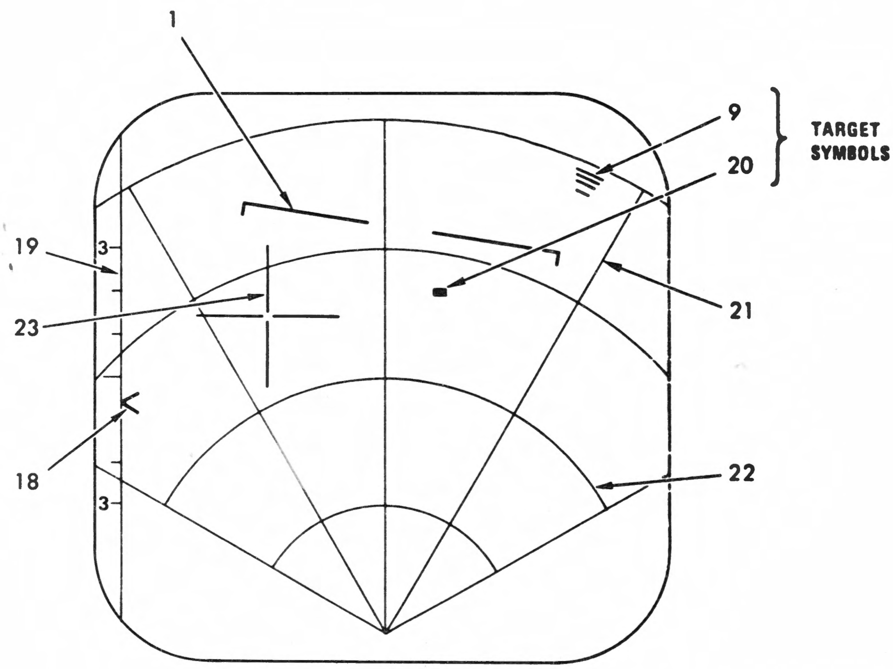


Figure 1-167. ANMI Symbology (Sheet 1 of 2)

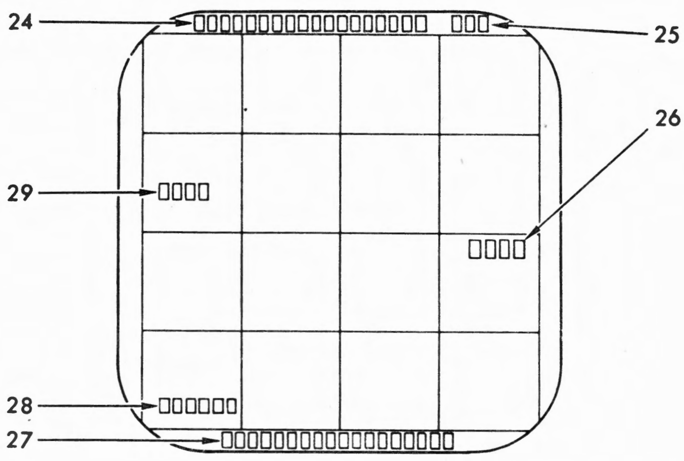


Figure 1-167. ANMI Symbology (Sheet 2)

Table 1-129. ANMI Symbology

Index No. (fig. 1-167)	Symbol	Description
1 (sh 1)	Horizon line	Appears during all modes. Horizon line is pitch and roll stabilized to provide attitude reference on the display.
1A (sh 1)	Destination indicator (A/A) and relative altitude triangle	Appears at steer-to point selected on NAV CONTROL panel (figure 1-140) when steer-to coordinates are within the range/azimuth limits of the display. Symbol appears for all radar ranges, except the 10 nmi range. Center of symbol indicates steer-tc coordinates. In PSP configuration only, replaces target symbols of targets that are more than 1000 (±250) feet above altitude of priority target or antenna scan center.
1B (sh 1)	Relative altitude triangle	Appears in PSP configuration only, when RAM relative altitude display is selected. Replaces target symbols of targets that are more than 1000 (±250) feet below altitude of priority target or antenna scan center.

Table 1-129. ANMI Symbology (Continued)

Index No. (fig. 1-167)	Symbol	Description
2 (sh 1)	Acquisition symbol	Appears during A/A search modes. Symbol position is varied in range and azimuth by using TDC switch (8, figure 1-69). Acquisition is enabled by bracketing radar target symbol (11, sheet 1) and depressing and releasing TDC switch. Simulated radar set inputs acquisition symbol range to simulated central computer for computation of radar beam altitude coverage for that range.
3 (sh 1)	R max 1 index	Appears at right edge of display during A/A track modes. Index indicates selected simulated A/A missile maximum launch range against a non-maneuvering target. Index uses horizontal grid lines (15, sheet 1) as a reference to indicate range.
4 (sh 1)	R max 2 index	Appears at right edge of display during A/A track modes. Index indicates selected simulated A/A missile maximum launch range against a maneuvering target. Index uses horizontal grid lines (15, sheet 1) as a reference to indicate range. During SRM attacks, only one R max index appears.
5 (sh 1)	Range to target caret	Appears at right edge of display during A/A track modes. Caret moves vertically and indicates simulated target range from simulated aircraft. Caret uses horizontal grid lines (15, sheet 1) as a reference to indicate range.
6 (sh 1)	Break X	Appears at center of display during A/A track modes when range to target is less than computed minimum range. Symbol indicates when to break off attack or approach to prevent damage to simulated aircraft.

Table 1-129. ANMI Symbology (Continued)

Index No. (fig. 1-167)	Symbol	Description
6 (cont) (sh 1)	Break X (cont)	During AIM-9 attacks, symbol flashes when target range is less than computed minimum range. During AIM-7 attacks, symbol is constant while missile is in flight. Symbol flashes when missile flight time elapses.
7 (sh 1)	R min index	Appears at right edge of display during A/A track modes. Index indicates minimum launch range for any missile firing. Index uses horizontal grid lines (15, sheet 1) as a reference to indicate range.
7A (sh 1)	Open radar target	Appears during PSP configuration only, when RAM search or RAM track is selected. Indicates detected targets that are not in track file.
8 (sh 1)	Mode X target	Appears during A/A modes when a mode X identification command is received by simulated central computer.
9 (sh 1)	Beacon coded target	Appears during A/A or A/G BCN modes. Bottom marker indicates range to beacon station using horizontal grid lines (15, sheet 1) as a reference. The number of additional markers and spacing between them represents beacon station code.
10 (sh 1)	IFF targets	Appear on display in A/A modes during IFF interrogation. IFF target replaces radar target (11, sheet 1) and is displayed as a diamond or circle to indicate confidence level of target being a friend. Diamond indicates lowest confidence level. Circle indicates highest confidence level.
11 (sh 1)	Solid radar target	In NON PSP configuration, appears during A/A modes when simulated radar set detects a target. Symbol position corresponds to actual target range (range rate in VS mode) and azimuth position.

Table 1-129. ANMI Symbology (Continued)

Index No. (fig. 1-167)	Symbol	Description
11 (cont) (sh 1)	Solid radar target (cont)	In PSP configuration, appears when simulated radar set detects a target if RAM search or RAM track is not selected. Symbol position corresponds to actual target range (range rate in VS mode) and azimuth position. If RAM search or RAM track is selected, appears to indicate a detected target that is in track file. Symbol position corresponds to relative position to center of designated area in RAM search or relative position to priority target in RAM track.
12 (sh 1)	Pulse mode target	Appears during A/A pulse mode. Pulse mode targets are displayed according to amplitude of radar return.
13 (sh 1)	Antenna azimuth caret	Appears at bottom of display during A/A modes. In A/A search mode, caret moves horizontally along antenna azimuth scale (14, sheet 1) and indicates simulated radar antenna position. In A/A track mode, caret position indicates relative azimuth angle of target. In PSP configuration only, with RAM search selected, caret position indicates relative azimuth position of the designated area center with respect to the simulated F-15A. If RAM track is selected, the caret position indicates the relative azimuth position of the priority target with respect to the simulated F-15A.
14 (sh 1)	Antenna azimuth scale	Appears on bottom grid line during A/A modes. Scale is marked in increments of 10 degrees azimuth from 0 to 30 degrees on both sides of center vertical grid line, which is the 0 degree mark. Grid lines at far right and left of display are 60 degree marks.
15 (sh 1)	Grid lines	Appear during A/A modes. Lines are used to determine simulated target range and azimuth. During A/A VS mode, lines are used to determine target velocity.

Table 1-129. ANMI Symbology (Continued)

Index No. (fig. 1-167)	Symbol	Description
15(cont) (sh 1)	Grid lines (cont)	In all A/A modes, except VS, space between horizontal line represents one-fourth of the selected radar range. In VS mode, each space represents 750 feet per second (approximately 450 knots). In all A/A modes, space between vertical grid lines represents 30 degrees azimuth. In PSP configuration, with RAM search or RAM track selected, the space between the vertical grid lines represents 3.75 degrees azimuth for a total scan of ±7.5 degrees. The space between the horizontal grid lines is 2.5 nmi.
16 (sh 1)	Allowable steering error (ASE) circle	Appears during A/A track mode and is used with steering dot (17, sheet 1) to provide a steering reference. ASE circle diameter is fixed or variable depending upon selected missile and radar range data. ASE circle flashes when simulated radar antenna is within 10 degrees of gimbal limits.
17 (sh 1)	Steering dot	Appears during all A/A modes to provide steering reference for missile or gun attacks. Steering dot is to be kept inside ASE circle (16, sheet 1) for correct steering. Steering dot flashes when simulated radar antenna is within 10 degrees of gimbal limits.
18 (sh 1)	Antenna elevation caret	Appears during A/A and A/G modes at left side of display. Caret moves along antenna elevation scale (19, sheet 1) and indicates simulated radar antenna position. In A/A and A/G search modes, caret position indicates antenna elevation angle with respect to horizon.

Table 1-129. ANMI Symbology (Continued)

Index No. (fig. 1-167)	Symbol	Description
18 (cont) (sh 1)	Antenna elevation caret (cont)	Caret moves in increments of 1 degree corresponding to EL bar scan. EL bar scan center is positioned by using antenna elevation control (10, figure 1-69). In A/A and A/G track modes, caret position indicates target elevation angle with respect to simulated aircraft pitch angle. In PSP configuration only, with RAM search selected, caret position indicates designated area center elevation angle with respect to simulated aircraft pitch angle. With RAM track selected, caret position indicates priority target elevation angle with respect to simulated aircraft pitch angle.
19 (sh 1)	Antenna elevation scale	Appears at left edge of display during A/A and A/G modes. Scale is marked in increments of 10 degrees elevation from 0 to 30 degrees on both sides of center horizontal grid line, which is the 0 degree mark. Grid lines at top and bottom of display are 60 degree marks. Numbers at top and bottom of marked portion of scale indicate 30 degree mark.
19A	Priority target circle	A six-degree circle that appears only in PSP configuration with RAM track selected. Circle is used to represent priority target position.
20 (sh 1)	Ranging target	Appears during A/G ranging mode and indicates range from simulated aircraft to specified ground point.
21 (sh 1)	Azimuth sector lines	Appear during A/G modes to aid in determining simulated target azimuth. Vertical line in center of the display represents 0 degrees azimuth. Each line to left and right of center line represents 30 degrees azimuth for a total of 60 degrees azimuth indication on each side of center line.

Table 1-129. ANMI Symbology (Continued)

Index No. (fig. 1-167)	Symbol	Description
22 (sh 1)	Range grid lines	Appear during A/G modes to aid in determining simulated target range. Each arc, starting from bottom of display, represents one-fourth of the selected radar range.
23 (sh 1)	Cursor	Appears during ground map mode. Cursor position is varied in range and azimuth by using TDC switch (8, figure 1-69). Discrete IP's and targets are designated by cursor position. After designation (TDC switch released), cursor indicates target or IP position and is maintained on target or IP through use of navigational data.
24 (sh 2)	Window 1	An 18-character alphanumeric readout that appears above top grid line during A/A modes. Readout displays simulated radar set, target, and weapon data. a. FLOOD, SNIFF, or MN TK is displayed by characters 10 through 14 to indicate radar set special operating mode. b. MEM is displayed by characters 16 through 18 during track modes when radar set is maintaining track by extrapolation (track memory). c. JAM is displayed by characters 16 through 18 during track modes when radar set is operating in a jamming environment. d. AOJ is displayed by characters 16 through 18 during search modes when radar set senses a noise jamming environment. e. HOJ is displayed by characters 16 through 18 during search modes when radar set enters a home-on-jam mode against a noise jammer. f. UNC is displayed by characters eight through 10 during an A/G EO presentation when seeker head in EO-guided weapon uncages and begins tracking selected target.

Table 1-129. ANMI Symbology (Continued)

Index No. (fig. 1-167)	Symbol	Description
24 (cont) (sh 2)	Window 1 (cont)	g. STBY is displayed by characters one through four to indicate that POWER switch (1, figure 1-83) on RADAR panel is in STBY position. If POWER switch is placed directly from OFF to OPR or EMERG, STBY is displayed until the warmup sequence ends. h. TUNE is displayed by characters one through four to indicate that radar set is sending radar frequency energy to rear signal antenna for AIM-7 missile tuning. TUNE indication disappears when missiles are properly tuned or when the 2-minute missile tune sequence ends. i. Minimum and maximum scan coverage data are displayed by characters one through five. Characters one through three indicate minimum altitude coverage of simulated radar antenna in thousands of feet. Characters five through seven indicate maximum altitude coverage of radar antenna in thousands of feet. Coverage is computed by simulated central computer based on antenna scan pattern, simulated aircraft altitude, and acquisition symbol range. Characters one and five display a minus (-) sign when altitude is negative. When altitude is positive, characters one and five are blank. j. Track data are displayed by characters one through 10. Characters one through four indicate simulated target true airspeed in knots. Character six indicates simulated target g's. Characters eight through 10 indicate target aspect angle. Angle is displayed as a number and a letter. The number, one through 17, represents the degrees (10 to 170); the letter R, L, H, or T represents the direction (right, left, head, or tail). When H or T is displayed, characters eight and nine are blank. k. In PSP configuration only, with RAM search or RAM track selected, characters 16 through 18 display the azimuth coverage, in nautical miles, of the radar scan pattern at the designated area or priority target range. Character 16 indicates number of miles, character 17 is a dash representing a decimal point, and character 18 indicates tenths of miles.

Table 1-129. ANMI Symbology (Continued)

Index No. (fig. 1-167)	Symbol	Description
25 (sh 2)	Range scale window	A three-character alphanumeric readout that appears at right side of display above top horizontal grid line during A/A and A/G modes. Characters one through three indicate radar range that is selected manually by RANGE switch (2, figure 1-83) on RADAR panel, or range that is set automatically by the position of weapon/mode switch (3, figure 1-69) on right throttle. Readout is also affected by automatic range scale switching feature described in paragraph 1-64. During A/A VS mode, VS is displayed.
26 (sh 2)	Window 2	A four-character alphanumeric readout that appears to the left of range to target caret (5, sheet 1) during A/A track modes. Window moves vertically with caret and displays target closing rate. When closing rate is positive, character one displays a number. When rate is negative, character one displays a minus (-) sign. During VS mode, readout displays target velocity. Velocity readout is based on acquisition symbol (2, sheet 1) position.
27 (sh 2)	Window 3	An 18-character alphanumeric readout that appears at bottom of display in all modes. Readout displays simulated aircraft speed, attack, and weapon data. a. Simulated aircraft ground speed in knots is displayed by characters two through five. Character one displays G. b. Aircraft true airspeed in knots is displayed by characters 15 through 18. Character 14 displays T. c. HD ALT is displayed by characters seven through 12 during A/A modes when simulated radar set is angle tracking simulated target at a high altitude and launch computation requires a snap-up attack. HD ALT is an indication to hold present altitude. When indication is removed from display, snap-up attack may be executed.

Table 1-129. ANMI Symbology (Continued)

Index No. (fig. 1-167)	Symbol	Description
27 (cont) (sh 2)	Window 3 (cont)	d. IN RNG is displayed by characters seven through 12 during A/A SRM mode when target being tracked is in range of selected simulated missile. e. NO ZN is displayed by characters seven through 11 during AIM-7 attacks when central computer computes a no zone condition for weapon firing. NO ZN is displayed until an in-range condition is computed. f. Time remaining before weapon release is displayed by characters seven through 12 during A/G mode. During A/A mode, predicted AIM-7F time-of-flight is displayed to indicate seconds it would take for weapon to impact target when target range is between R max 1 and R min. Predicted time-of-flight readout is continuously updated until missile launch. At missile launch, actual time-of-flight countdown to zero seconds in real time begins. Actual time-of-flight countdown readout flashes to distinguish it from predicted time-of-flight readout. A maximum of 99 seconds can be displayed. Characters seven and eight indicate number of seconds. Characters 9 through 11 display SEC. g. In PSP configuration only, in RAM search, the range to the center of the designated area is displayed to the nearest nautical mile by characters 1 and 2 with NM displayed by characters 4 and 5. In RAM track, the range to the priority target is displayed.
28	BIT window	A six-character alphanumeric readout that appears above bottom grid line at left side of display during A/A modes. When BIT is initiated on BIT panel (figure 1-77) and POWER switch (1, figure 1-83) on RADAR panel is in STBY position, BIT fault matrix code is displayed. Additional simulated radar set data are also displayed in BIT window. a. TEST is displayed by characters three through six after airborne BIT initiation until other data are displayed.

Table 1-129. ANMI Symbology (Continued)

Index No. (fig. 1-167)	Symbol	Description
28 (sh.2)	BIT window (cont)	b. G-TEST is displayed by characters one through six after ground BIT initiation until other data are displayed. c. Antenna EL bar is displayed by character two during A/A search modes. Character two displays a number from one through eight to indicate current bar of any multi-bar antenna pattern. d. Pulse repetition frequency (PRF) is displayed by characters four through six during A/A search and track modes. Characters four and five display HI for high PRF or LO for low PRF. Characters four through six display MED for medium PRF. e. RF NG is displayed by characters two, three, five, and six when radar transmitter fails to transmit or transmits below normal power levels. f. Frame store number is displayed by characters four through six during beacon mode. Character six displays selected frame store number (1-7). Characters four and five display FS. g. Channel number selected by CHAN selector (5, figure 1-83) on RADAR panel is displayed during passive sniff mode. Characters one through four display CHAN. Character five is blank. Character six displays the channel number (1-6 or A). h. TK TST is displayed by characters one, two, four, five, and six approximately 7 seconds after OPR initiated BIT is selected. TK TST remains in window during track test if this option is selected. If track test is not selected, TK TST is removed from window after 7 seconds and G-TEST or TEST reappears. i. I-BIT is displayed by characters two through six preceding the readout of the operator initiated BIT fault matrix code.

Table 1-129. ANMI Symbology (Continued)

Index No. (fig. 1-167)	Symbol	Description
28(cont) (sh 2)	BIT window (cont)	j. CM-BIT is displayed by characters one through six preceding the readout of the continuous monitor BIT fault matrix code. k. NO-BIT is displayed by characters one through six for 7.5 seconds after initiated BIT has been terminated abnormally by selecting mode reject or placing RADAR panel POWER switch (1, figure 1-83) at OFF. m. I is displayed by character one during interrogation or AAI initiated BIT provided radar is not in an IFF inhibit mode. n. In PSP configuration only, RAM-S is displayed by characters 1 through 5 when radar is operating in RAM search mode. p. In PSP configuration only, RAM-T is displayed by characters 1 through 5 when radar is operating in RAM track mode.
29 (sh 2)	Window 4	A four-character alphanumeric readout that appears to the right of antenna elevation caret (18, sheet 1) during A/A modes when simulated radar set is tracking a target. Window moves vertically with caret and indicates simulated target absolute altitude in thousands of feet. In PSP configuration only, with RAM track selected, window indicates priority target elevation in thousands of feet. Characters one and two display altitude in thousands of feet. Character three displays a dash (-) representing a decimal point. Character four displays altitude in hundreds of feet. An absolute altitude of 99,900 feet is displayed as 99-9.

1-58. The primary A/A modes are long range search (LRS), velocity search (VS), and short range search (SRS). These modes are designed to fit a particular environment and are used for simulated airborne target detection and acquisition. The pulse mode serves as a backup for the LRS, VS, and SRS modes.

1-59. The A/A automatic acquisition modes consist of boresight, supersearch, vertical scan, and automatic gun. The boresight mode serves as an automatic acquisition mode for targets within 10 nautical miles along the simulated aircraft boresight line. The supersearch mode serves as the primary radar mode for targets within the HUD field of view up to a range of 10 nautical miles. The vertical scan mode serves as an automatic acquisition mode for targets within 10 nautical miles and a +5 degree to +45 degree elevation and two-bar azimuth scan pattern normal to the simulated aircraft lateral axis. The automatic gun mode serves as an additional automatic acquisition mode for targets within 10 nautical miles and a 60 degree azimuth and six-bar, +17 degree elevation scan pattern. For more details on automatic acquisition modes, refer to T.O. 1F-15A-2-25.

1-60. The primary A/G modes are ground map and ranging. In these modes, the ANMI displays simulated ground target and terrain data.

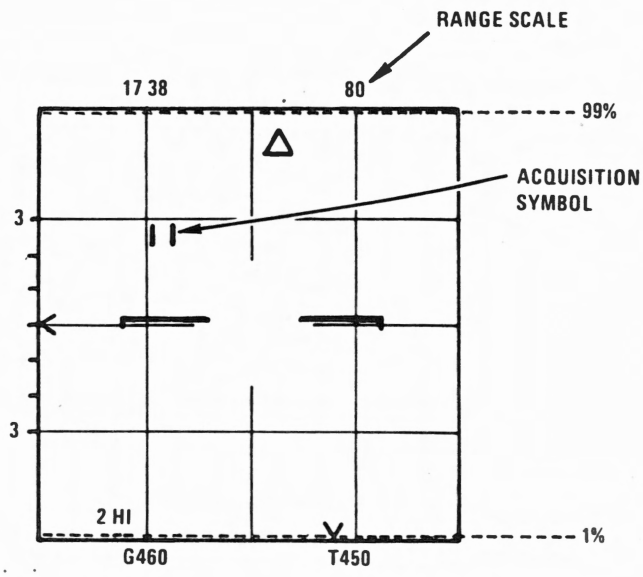
1-61. The beacon (BCN) mode may be used in A/A or A/G operations. The BCN mode provides interrogation of beacon transponders.

1-62. The electronic counter-countermeasures (ECCM) modes are jam (JAM), angle of jam (AOJ), and home on jam (HOJ). These modes are used to detect and track jamming devices.

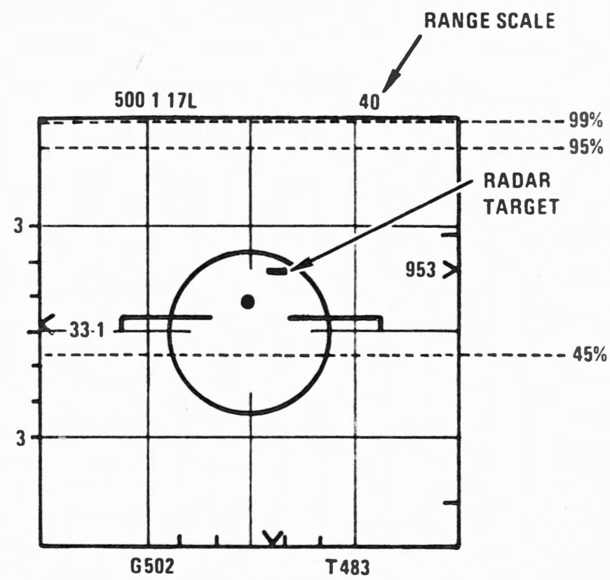
1-63. Frame storage, special radar mode, and built in test (BIT) displays are explained in paragraphs 1-80 through 1-85.

1-64. Automatic Range Scale Switching. Initial range scale settings are determined by the position of the weapon/mode switch (3, figure 1-69) on the right throttle grip. In automatic A/A search modes, the initial range scale setting can be changed automatically to a higher or lower range scale by positioning the acquisition symbol (2, figure 1-167, sheet 1) on the ANMI display (figure 1-90) to the top or bottom of the display, using the target designator control (TDC) switch (8, figure 1-69) on the right throttle grip. When the acquisition symbol is positioned beyond 99 percent of the display range scale, the next higher range scale is automatically selected. When the acquisition symbol is positioned to less than 1 percent of the display range scale, the next lower range scale is automatically selected (see figure 1-168). When the next higher or lower range scale is automatically selected, the acquisition symbol is automatically repositioned to the center of the display. In track modes, the range scale is automatically changed as the target moves on the ANMI display. If the target moves up beyond 95 percent (99 percent in the 10 nautical mile range) of the display range scale, the next higher range scale is selected. When the target moves down to less than 45 percent of the full scale, the next lower range scale is selected (see figure 1-168).

1-65. Typical Displays in the A/A Mode. When the simulated radar set is in the LRS mode, ANMI symbols display detection and acquisition data for simulated airborne targets that have both closing and opening rates. When simulated radar set locks on to the target, a track display appears. Typical LRS displays are shown in figures 1-169 and 1-170.



SEARCH



TRACK

3150S2887

Figure 1-168. Automatic Range Scale Switching

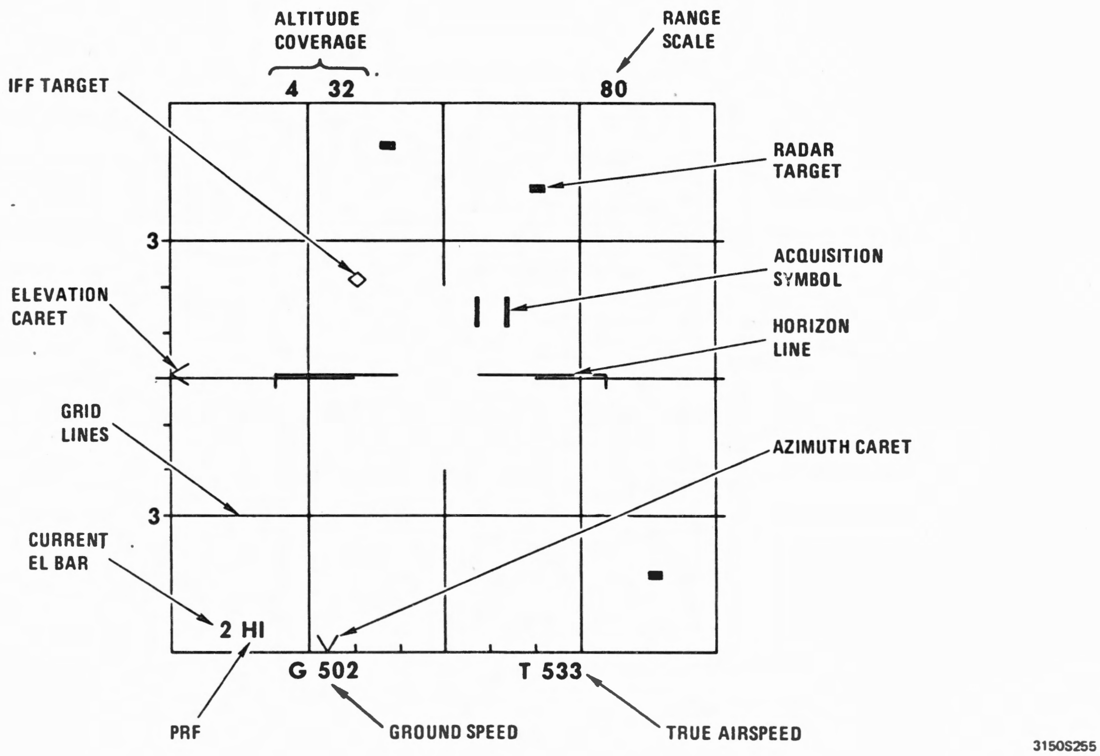
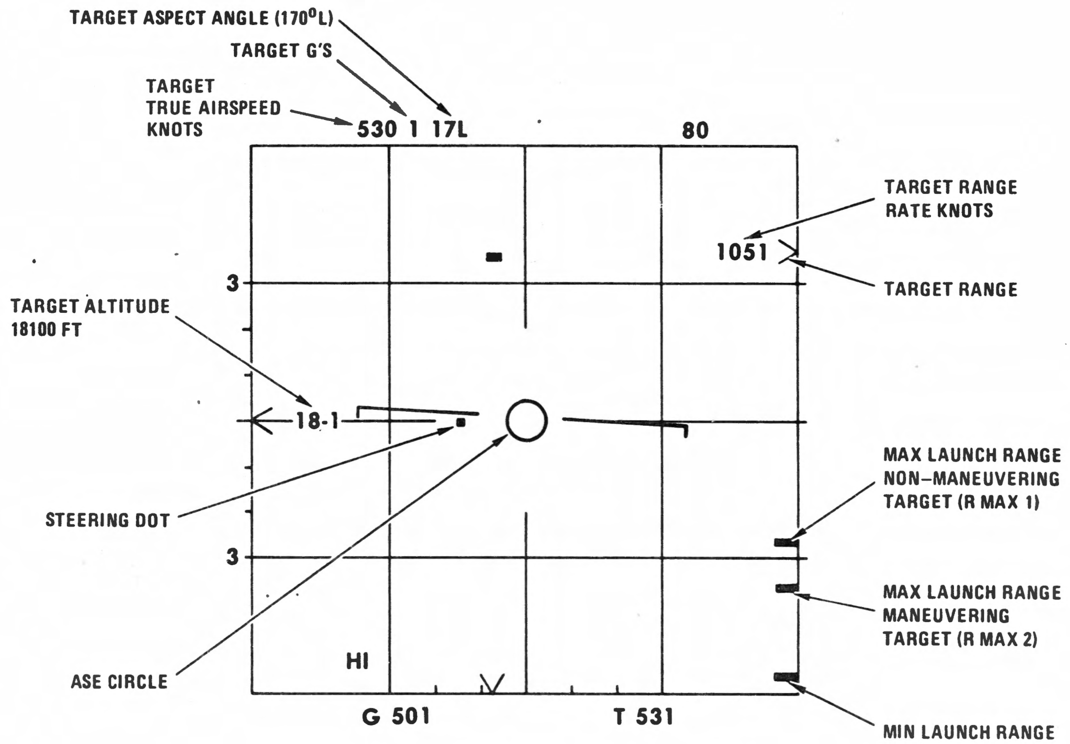
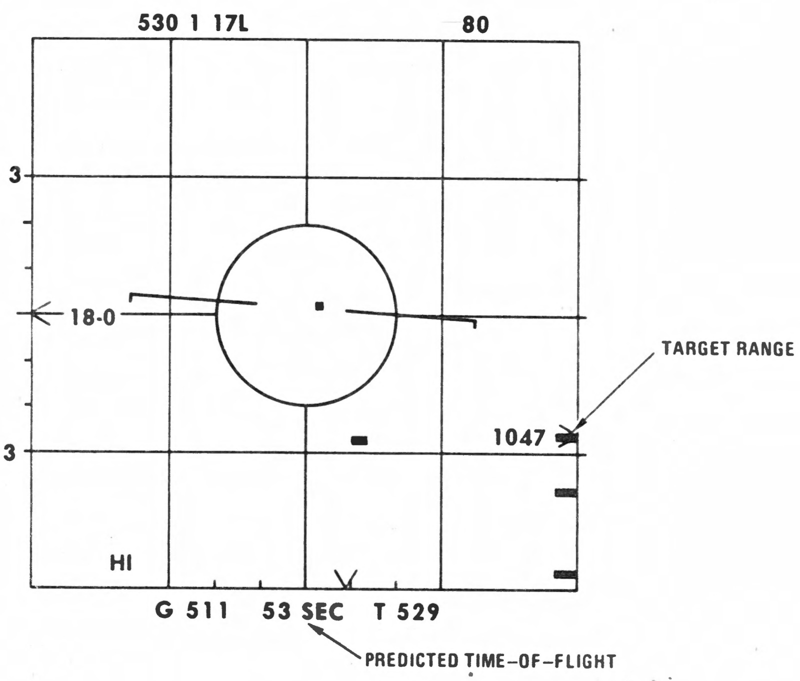


Figure 1-169. LRS Search Display



IN RANGE



3150S256A

Figure 1-170. LRS Track Displays (Sheet 1 of 2)

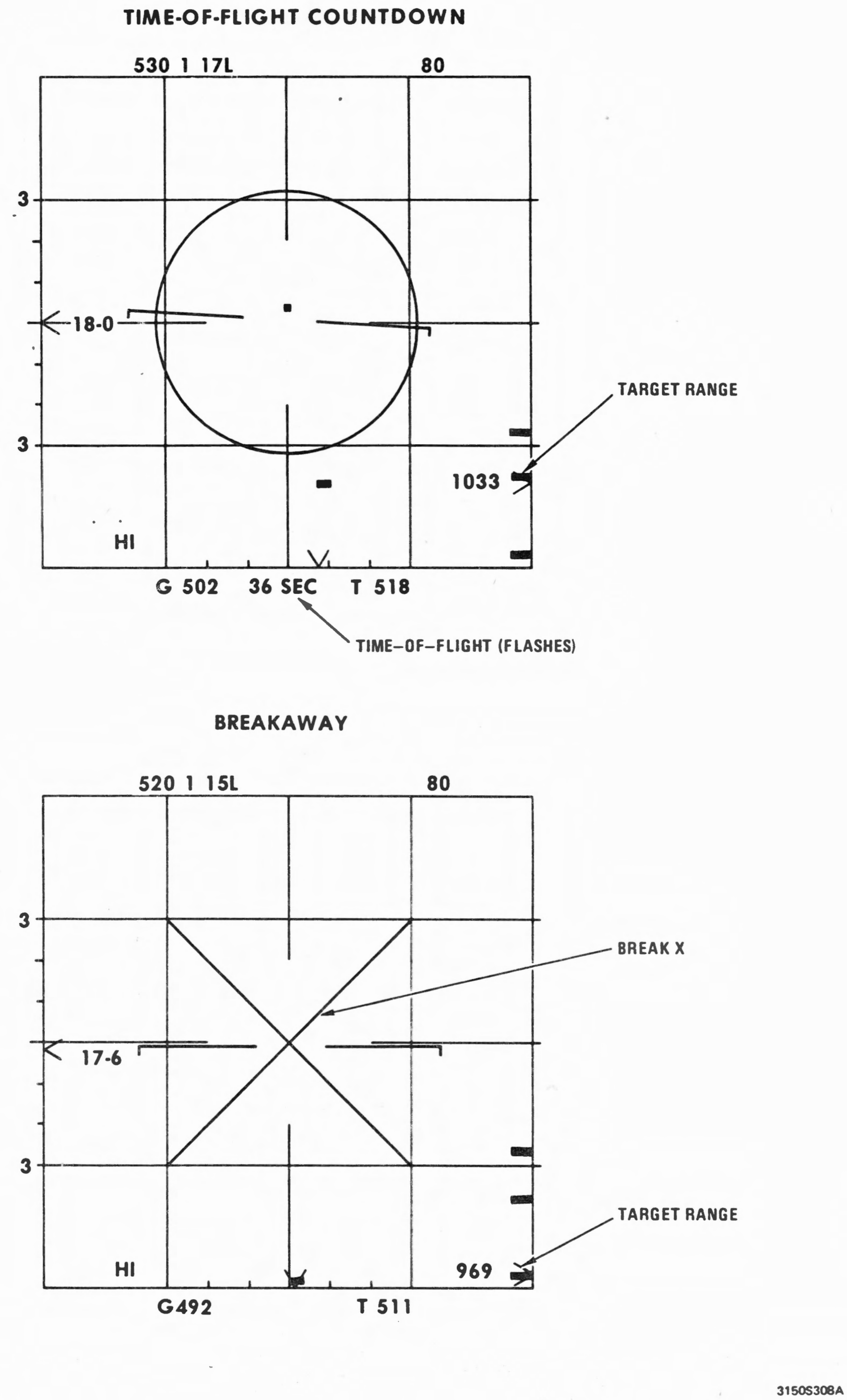


Figure 1-170. LRS Track displays (Sheet 2)

1-66. In the VS mode, ANMI symbols display detection and acquisition data for simulated airborne targets that have high closing rates. Only closing rate targets are detected and displayed. Targets are detected at ranges greater than those in the LRS mode. Data is displayed in velocity versus azimuth. When the target range is computed, a track display appears. Typical VS displays are shown in figures 1-171 and 1-172.

1-67. In LRS or VS search modes, the radar periodically enters a doppler mode to update the velocity data used by the radar. The mode is automatic and occurs every 7 minutes. The simulated antenna is driven down and alternately to the left and right to obtain ground velocity information. During this 3-second update period, the display on the ANMI is frozen and the antenna elevation caret and azimuth caret (18 and 13, figure 1-167, sheet 1) are positioned to 0 degrees. The normal search display is resumed after the 3-second update period ends.

1-68. In the SRS mode, ANMI symbols display detection and acquisition data for simulated airborne closing and opening rate targets within 40 nmi of the simulated aircraft. Data is displayed in range versus azimuth. The SRS mode is limited to a 40 nmi range regardless of the radar range selected by RANGE switch (2, figure 1-83). After the simulated radar set locks on to the target, a track display appears. Typical SRS displays are shown in figures 1-173 through 1-175.

1-69. In the pulse mode, ANMI symbols display detection and acquisition data for simulated airborne targets that have closing and opening rates. Data is displayed in range versus azimuth. Targets are displayed according to the amplitude of the radar return. When the simulated radar set locks on to the target, the display that appears depends on the weapon selected. A typical pulse display is shown in figure 1-176.

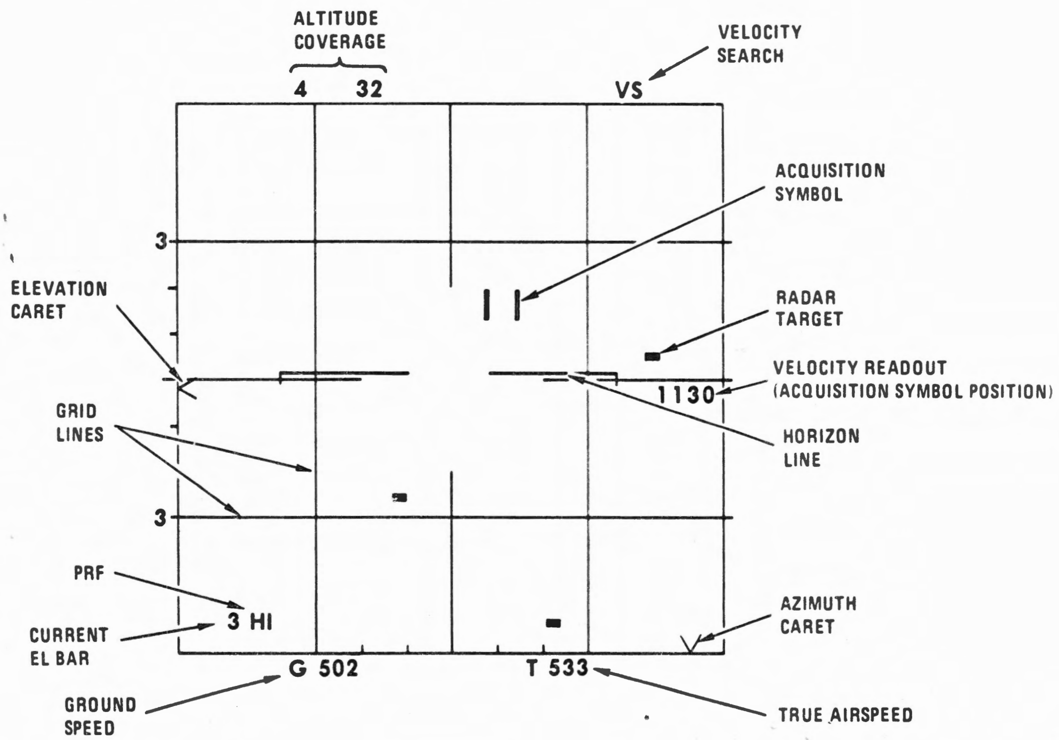


Figure 1-171. VS Display

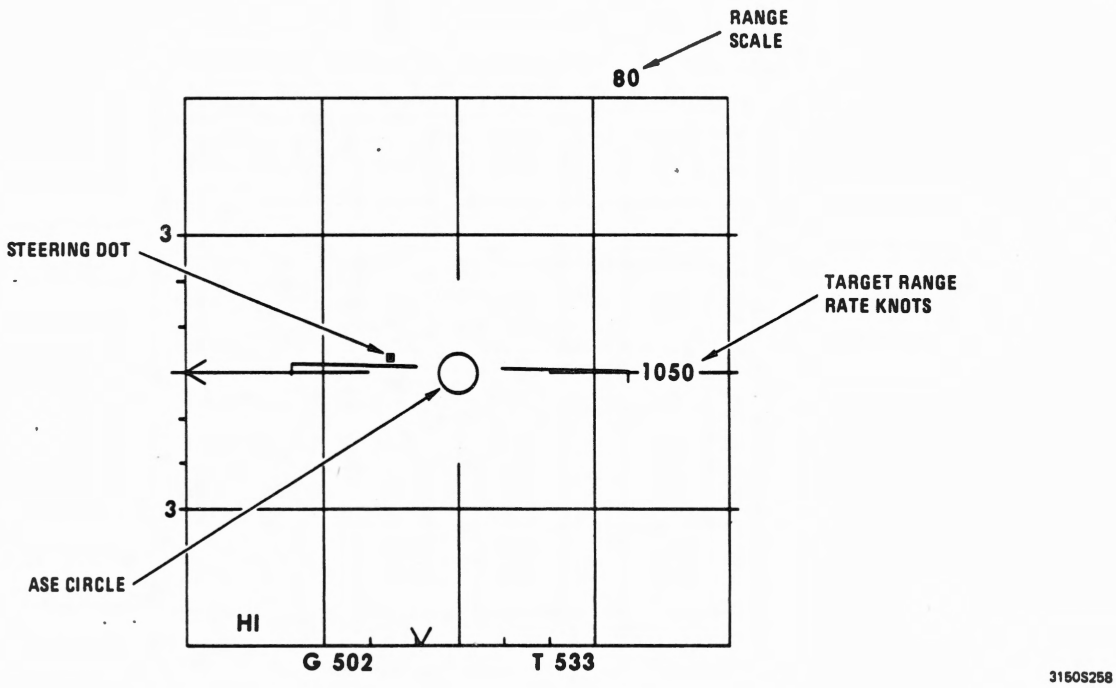


Figure 1-172. Initial VS Track Display

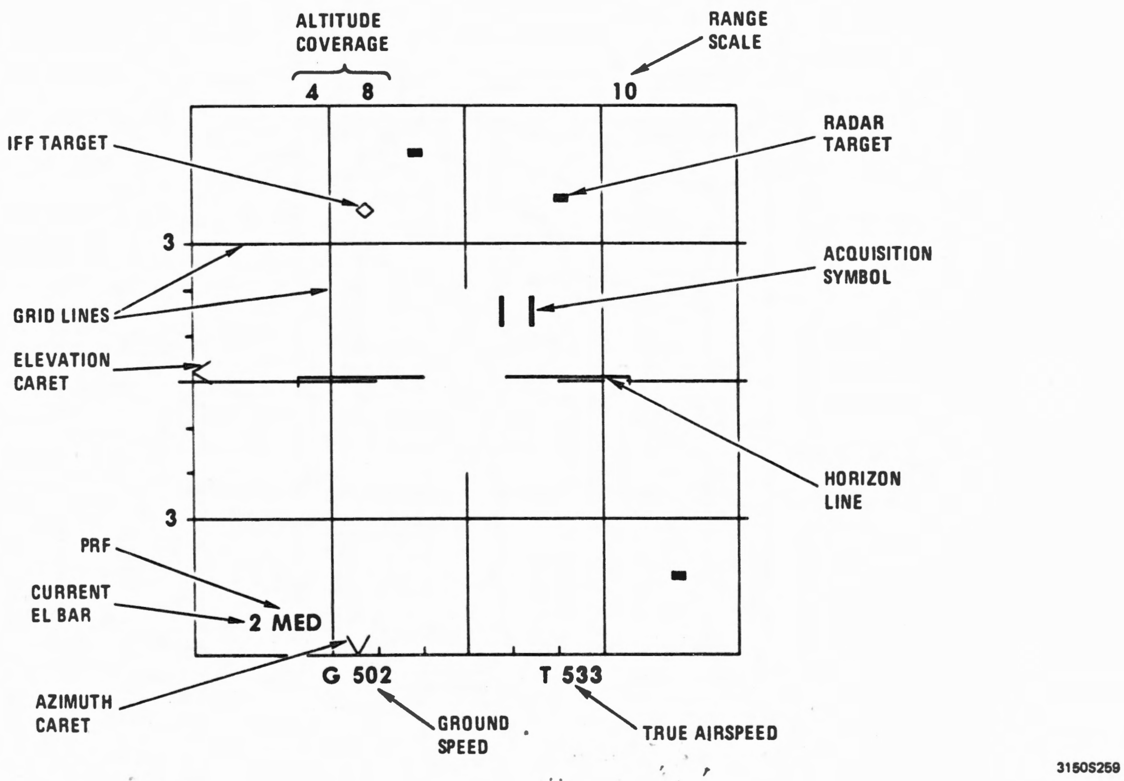


Figure 1-173. SRS Search Display

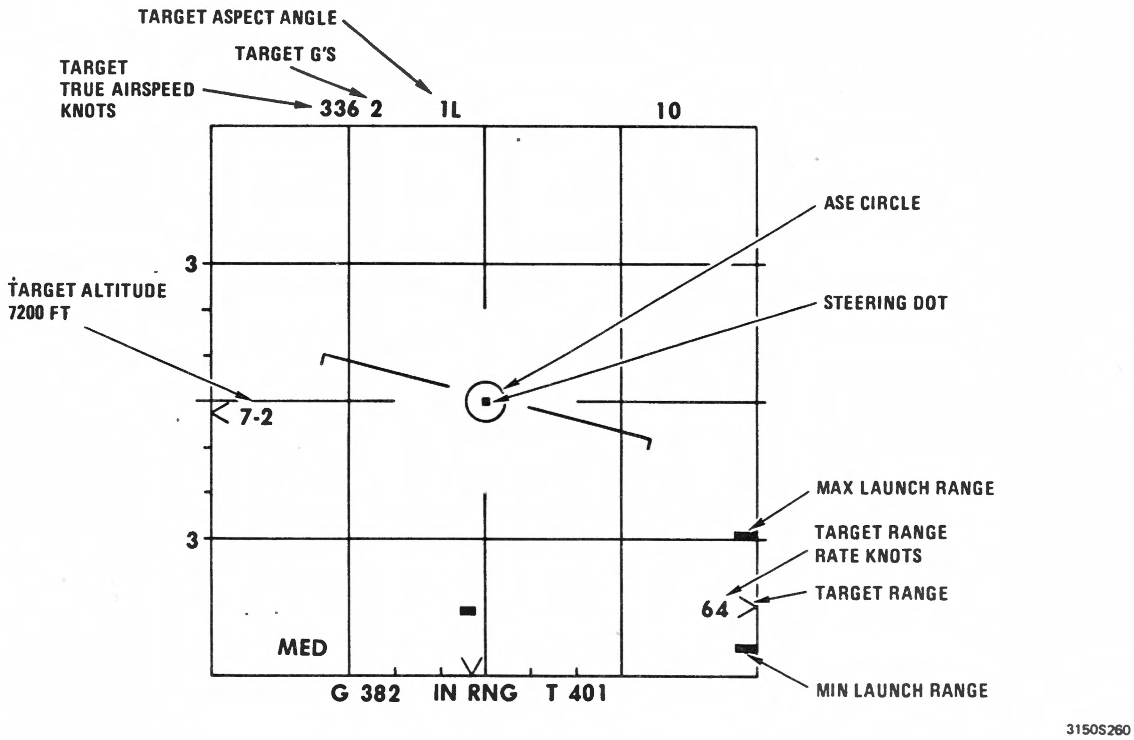


Figure 1-174. SRS Track Display

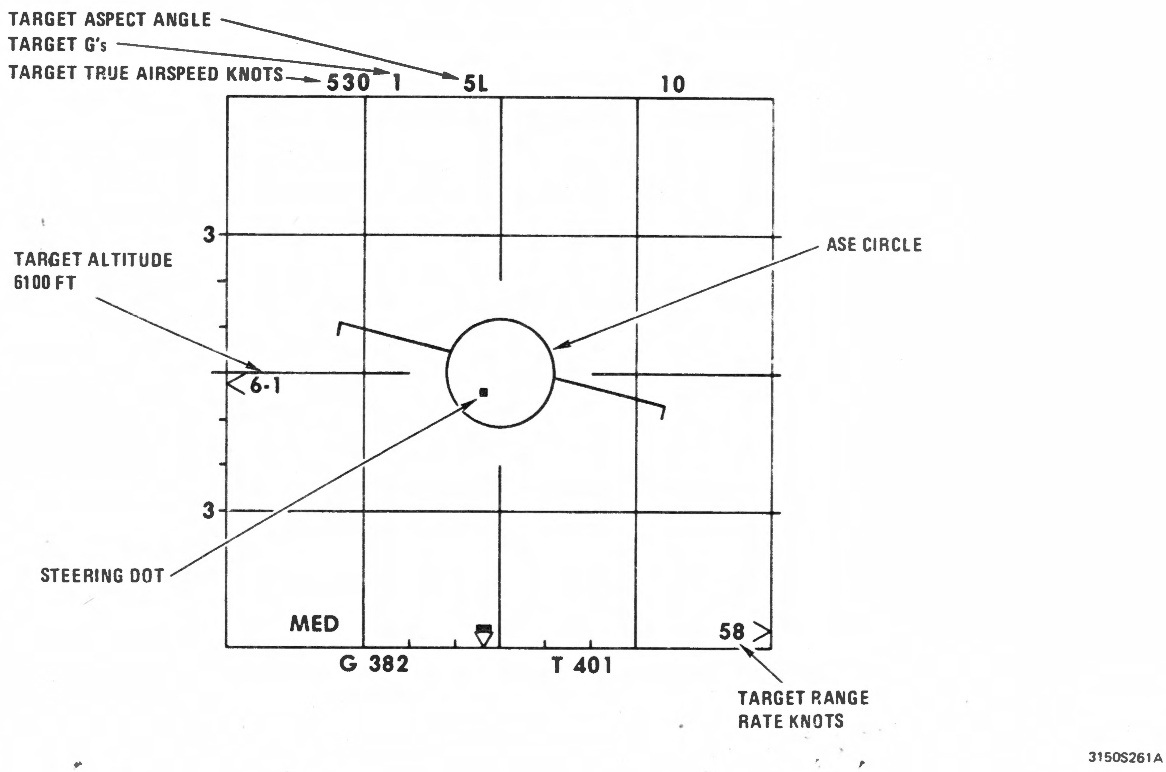


Figure 1-175. SRS Gun Track Display

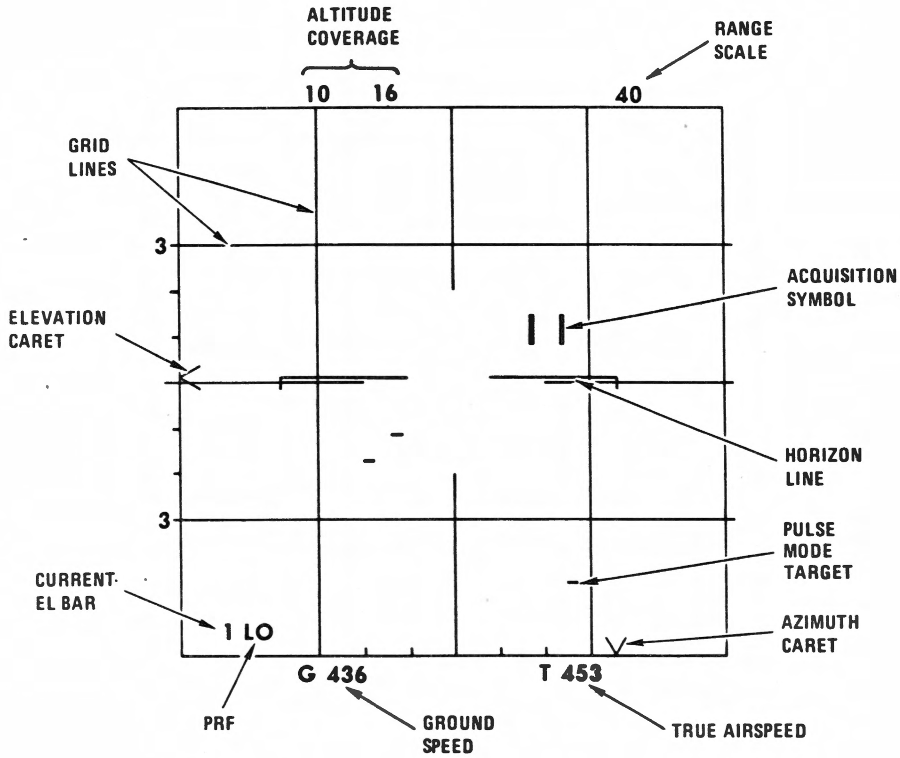


Figure 1-176. Pulse Display

1-69A. In the Raid Assessment Mode (RAM), available only in PSP configuration, the radar has the capability of maintaining tracking information on up to four targets (one priority target and three others). This enables the radar to detect, resolve, and track multiple targets in the event of a clustered raid. Targets in the track file (the up to four targets tracked) are displayed as solid symbols and other detected targets are open symbols. Search, track, and relative altitude displays are available in RAM. The relative altitude display indicates altitude of targets relative to altitude of antenna scan center or priority target. Typical RAM displays are shown in figures 1-176A through 1-176C.

1-70. The ANMI symbols are also shown in figure 1-167 and described in table 1-129.

1-71. Typical Display in the VI Mode. In the VI mode, the ANMI displays a track display similar to the SRS track display (see figure 1-174). ANMI symbols display steering data necessary to guide the simulated aircraft behind and slightly below the simulated target for a visual identification. The ANMI symbols are also shown in figure 1-167 and described in table 1-129.

1-72. Typical Displays in the A/G Mode. When the simulated radar set is in the ranging mode, ANMI symbols display simulated ground target data in range versus azimuth. The ranging mode is used to determine the slant range from simulated aircraft to a specified ground point. This mode is used primarily for bombing. A typical A/G ranging display is shown in figure 1-177.

1-73. In the ground map mode, the ANMI displays a radar return of the simulated ground terrain. A typical ground map display is shown in figure 1-178.

1-74. In the doppler mode, simulated radar set performs a navigational data update. The ANMI displays only the simulated aircraft true airspeed and ground speed in window 3. A typical doppler display is shown in figure 1-179.

1-75. The ANMI symbols are also shown in figure 1-167 and described in table 1-129.

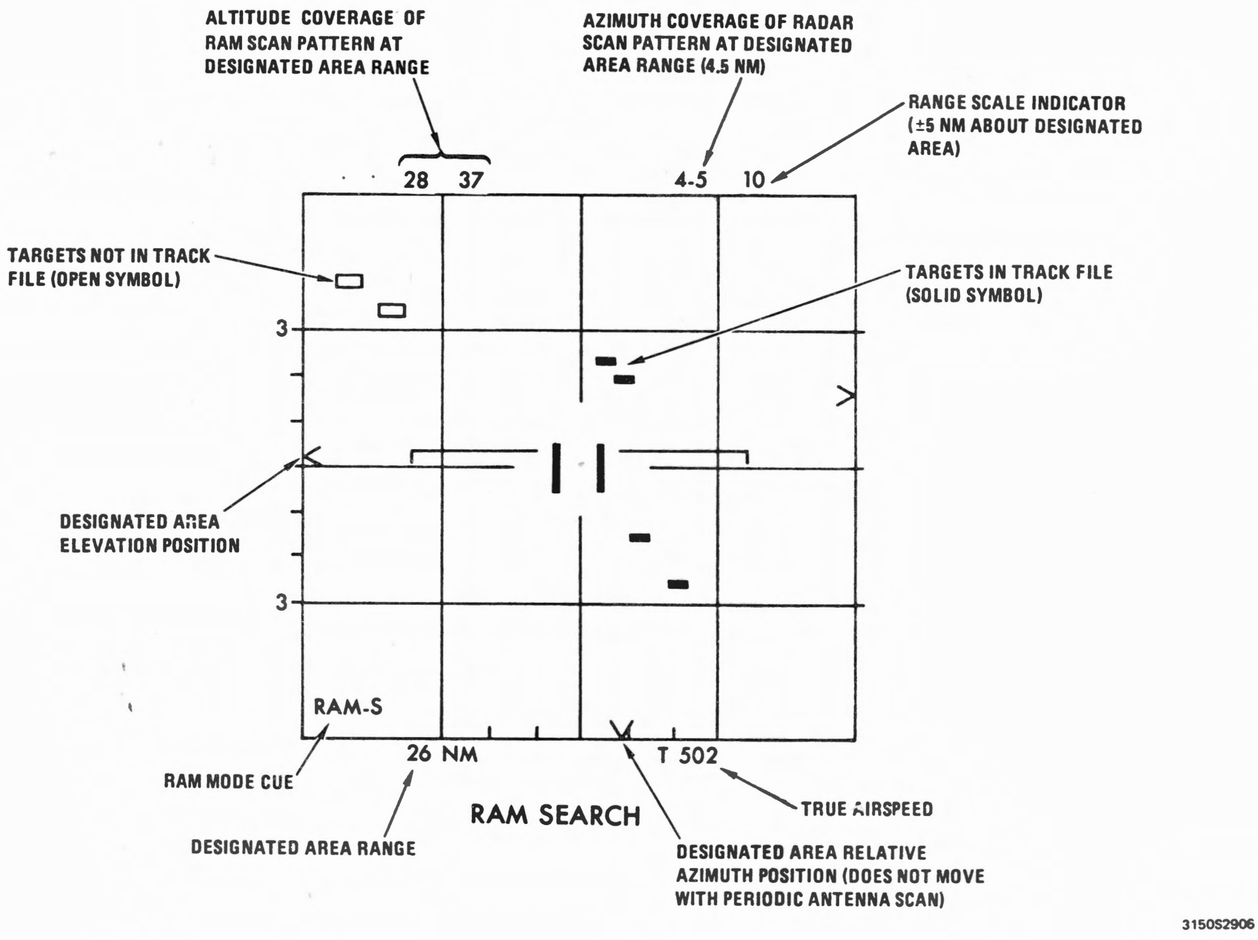


Figure 1-176A. Typical RAM Search Display

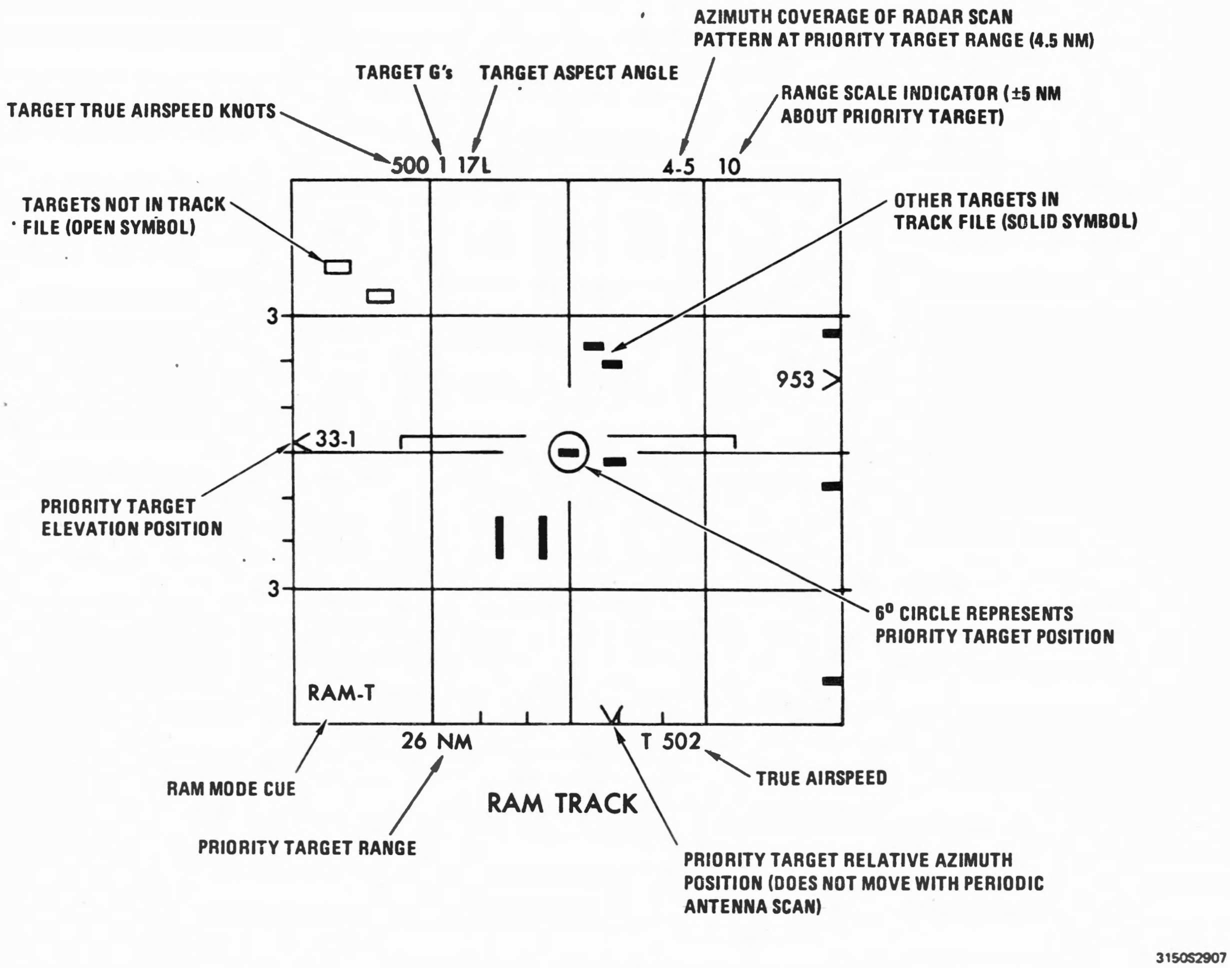


Figure 1-176B. Typical RAM Track Display

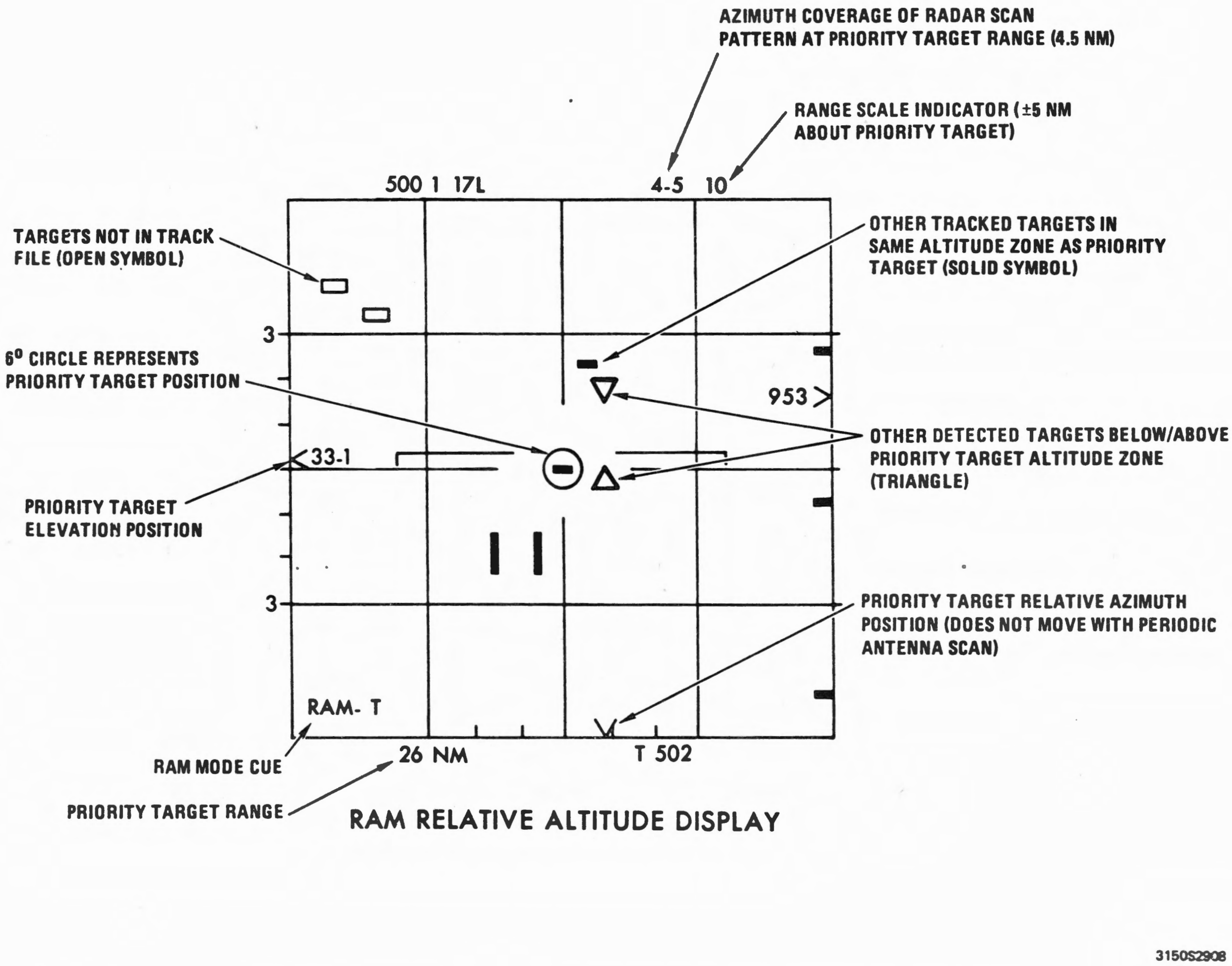


Figure 1-176C. Typical RAM Relative Altitude Display

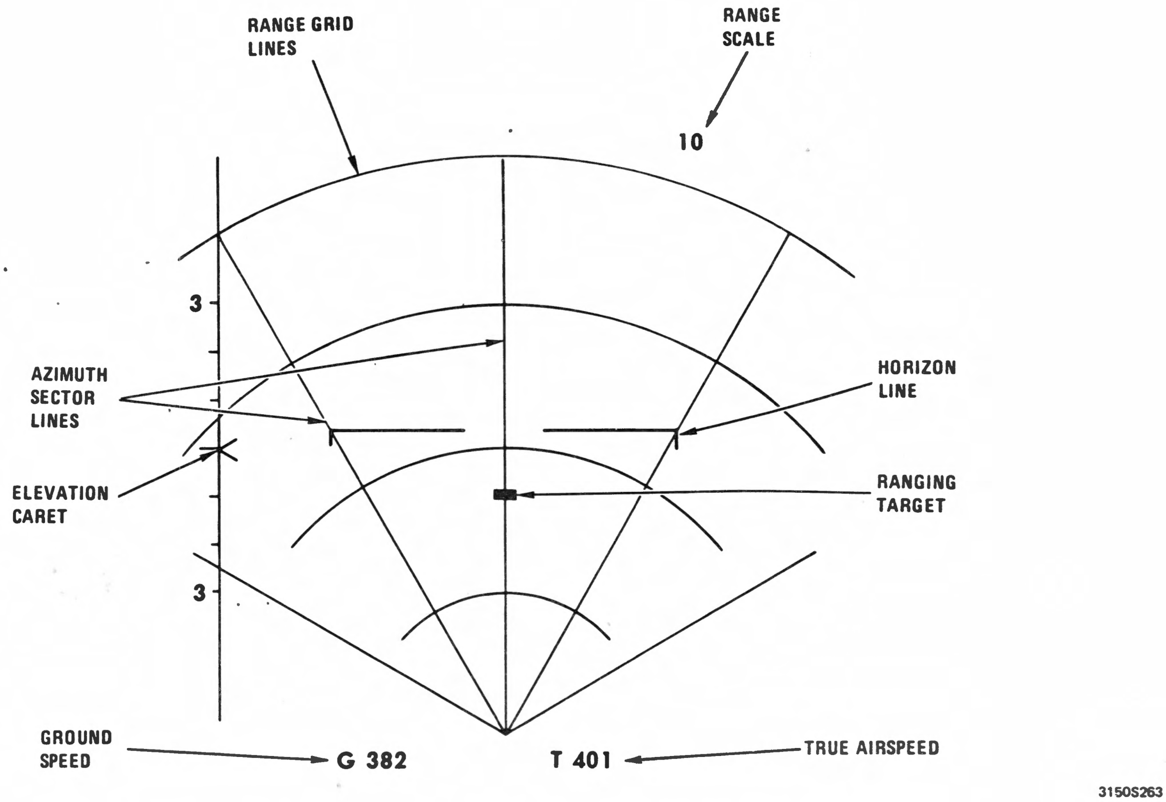


Figure 1-177. A/G Ranging Display

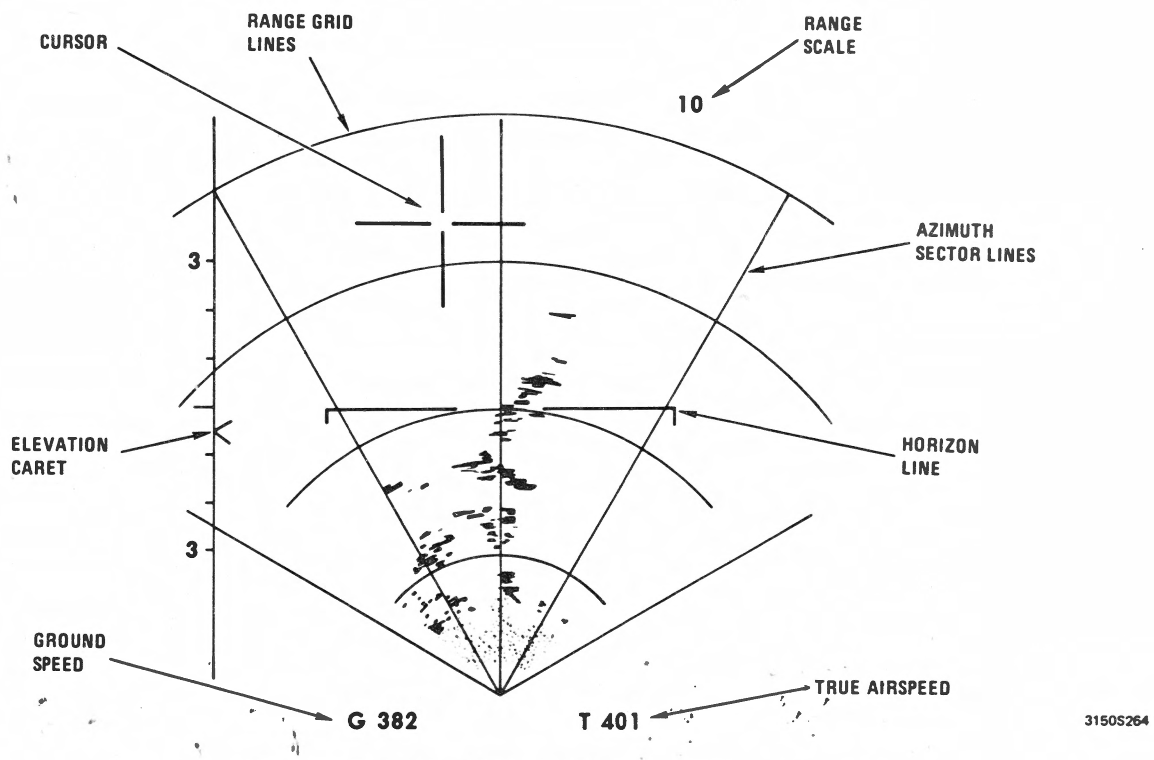


Figure 1-178. Ground Map Display

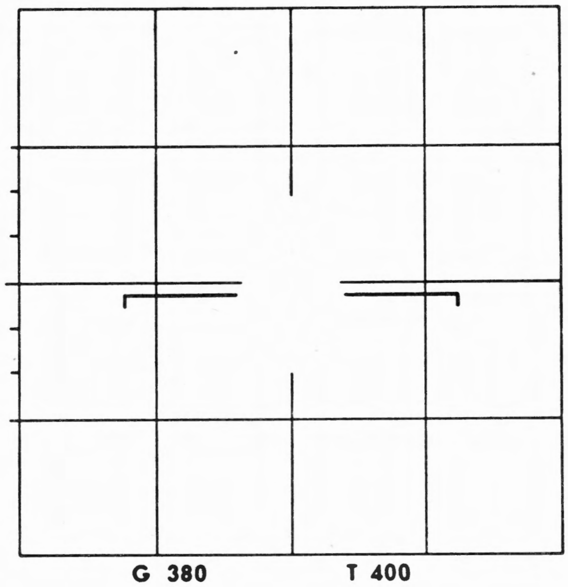


Figure 1-179. Doppler Display

1-76. Typical Displays in the Beacon Mode. When the simulated radar set is in the BCN mode, beacon transponders are interrogated and the ANMI symbols display the beacon replies. The BCN mode is always A/A unless the A/G master mode is selected. Typical BCN displays in the A/A and A/G modes are shown in figure 1-180.

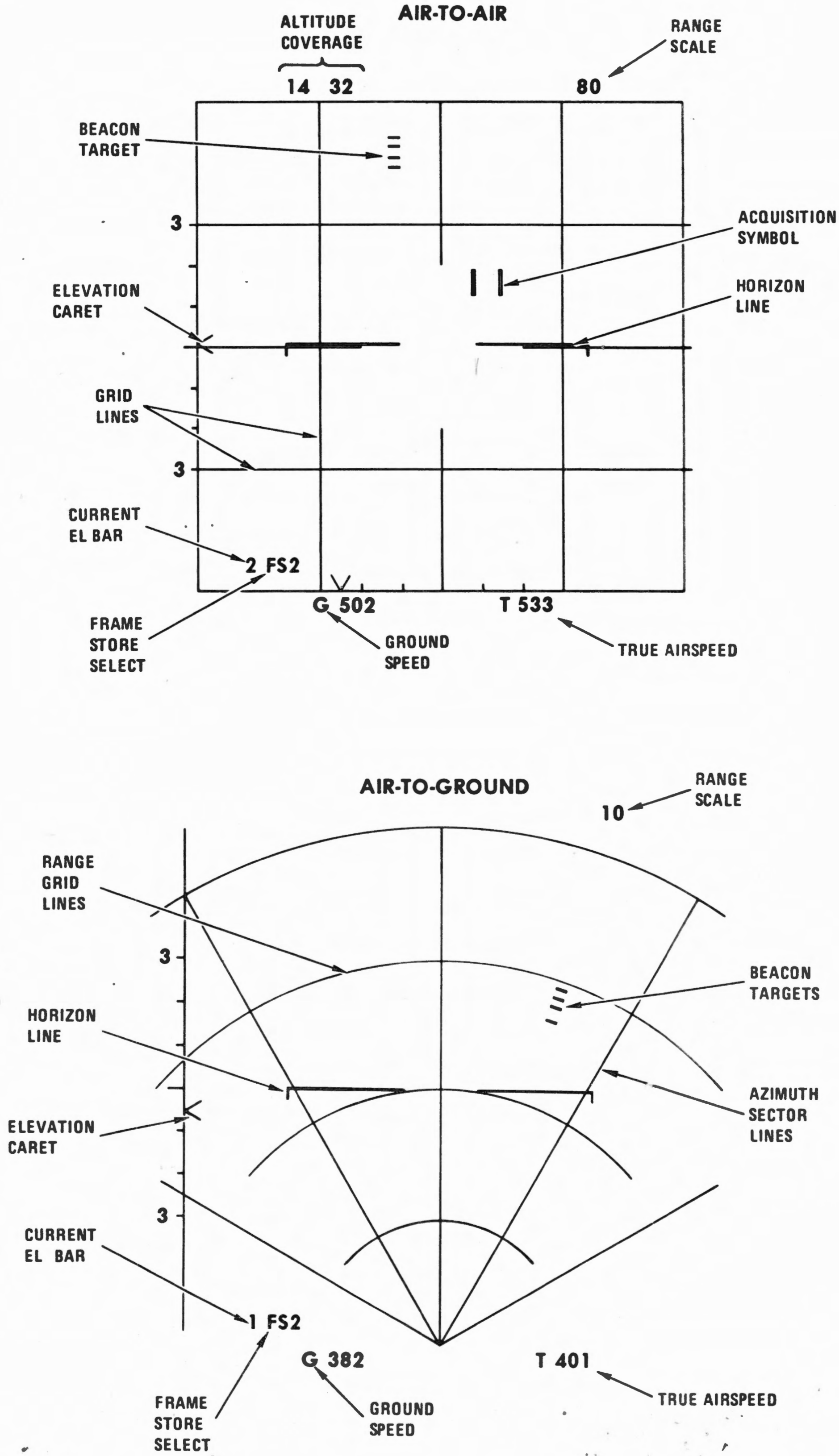
1-77. The ANMI symbols are also shown in figure 1-167 and described in table 1-129.

1-78. Typical Displays in ECCM Modes. The simulated radar set automatically switches to the ECCM modes in the presence of active electronic countermeasure (ECM) devices. ANMI symbols display detection and acquisition data for the search and tracking of ECM threats. The ECCM mode codes (JAM, AOJ, and HOJ) are displayed on the ANMI in window 1. In the AOJ mode, the AOJ strobe is a series of nine or 10 radar target symbols evenly spaced in range at the azimuth bearing of the ECM device. Typical ECCM displays are shown in figures 1-181 through 1-184.

1-79. The ANMI symbols are also shown in figure 1-167 and described in table 1-129.

1-80. Typical Frame Storage Display. In all search modes, ANMI symbols can display a target history. Depending upon the setting of FRAME STORE switch (10, figure 1-83), up to seven frames of stored data in the NON PSP configuration or up to three frames in the PSP configuration can be displayed on the ANMI. The first time a target is displayed it is at full brightness. As the target ages, its intensity is decreased according to its age. A typical frame storage display is shown in figure 1-185.

1-81. The ANMI symbols are also shown in figure 1-167 and described in table 1-129.



3150S265

Figure 1-180. BCN Displays

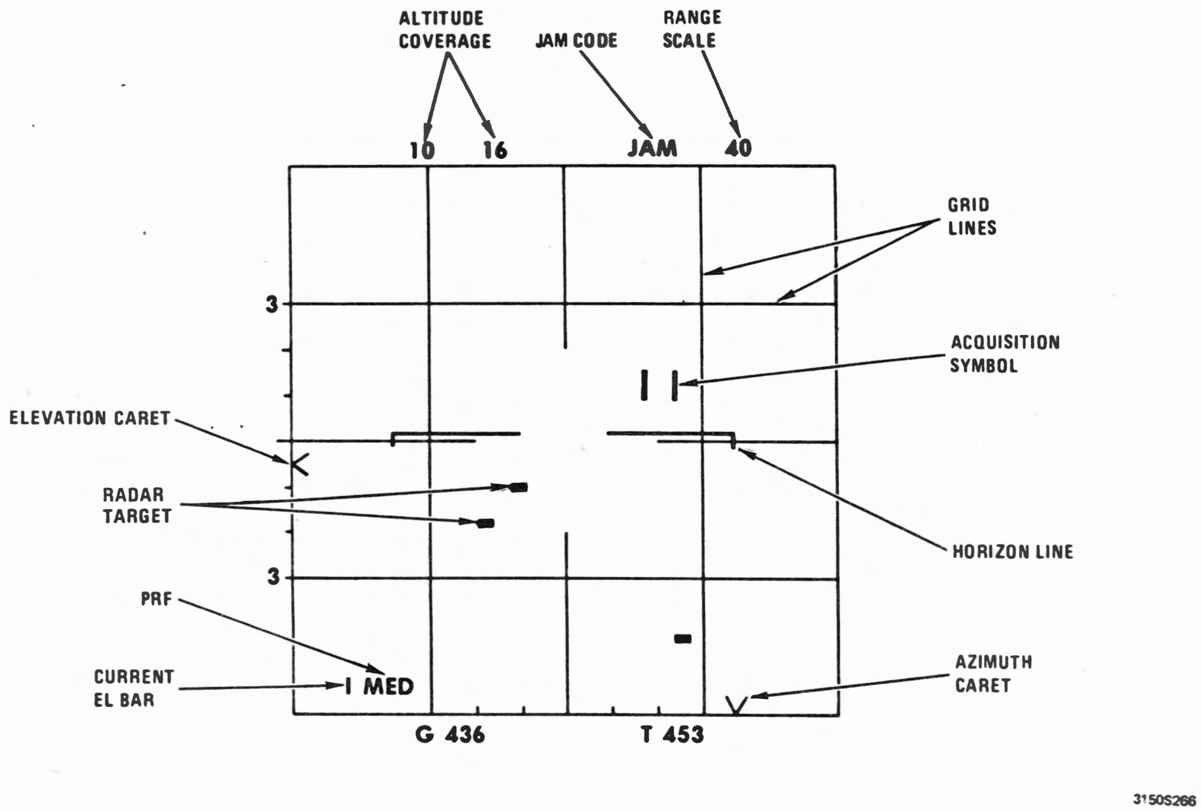


Figure 1-181. JAM Search Display

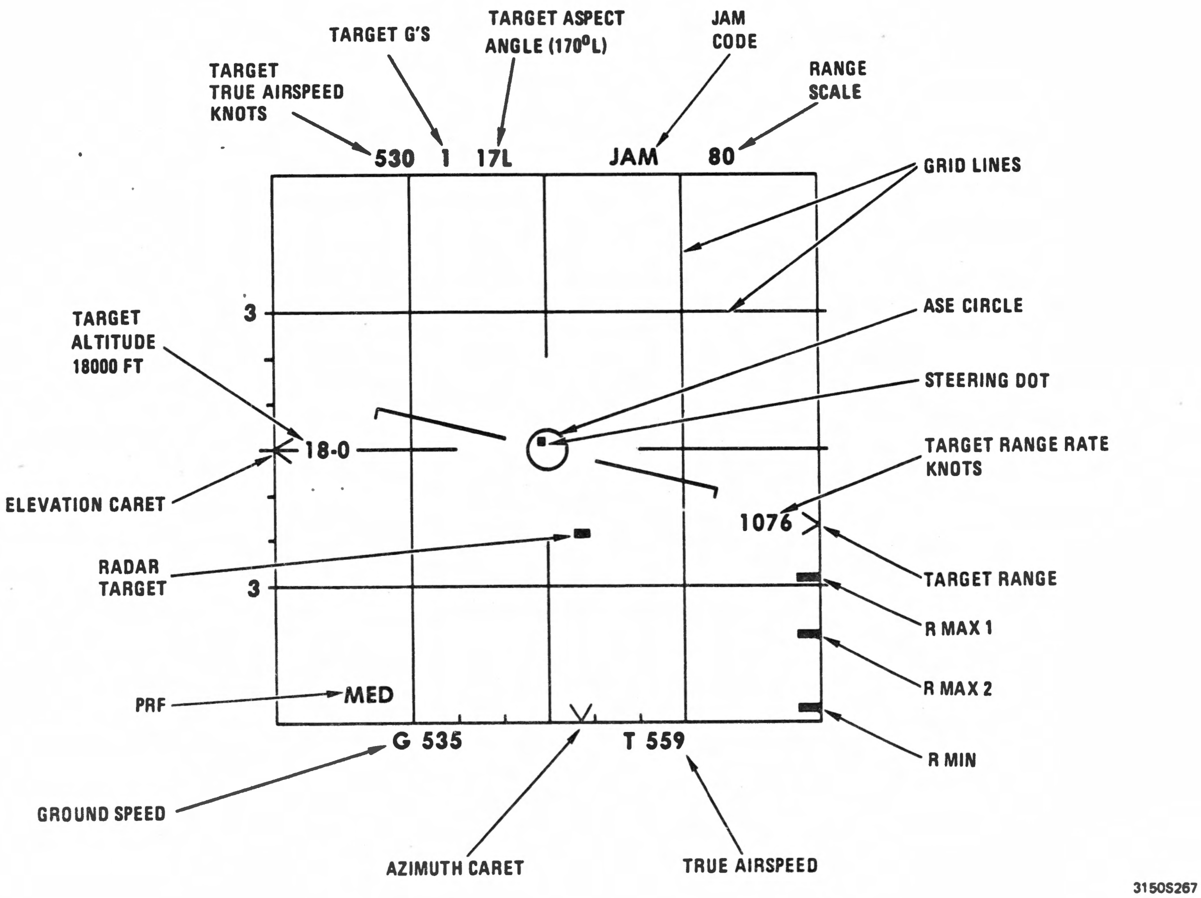


Figure 1-182. JAM Track Display

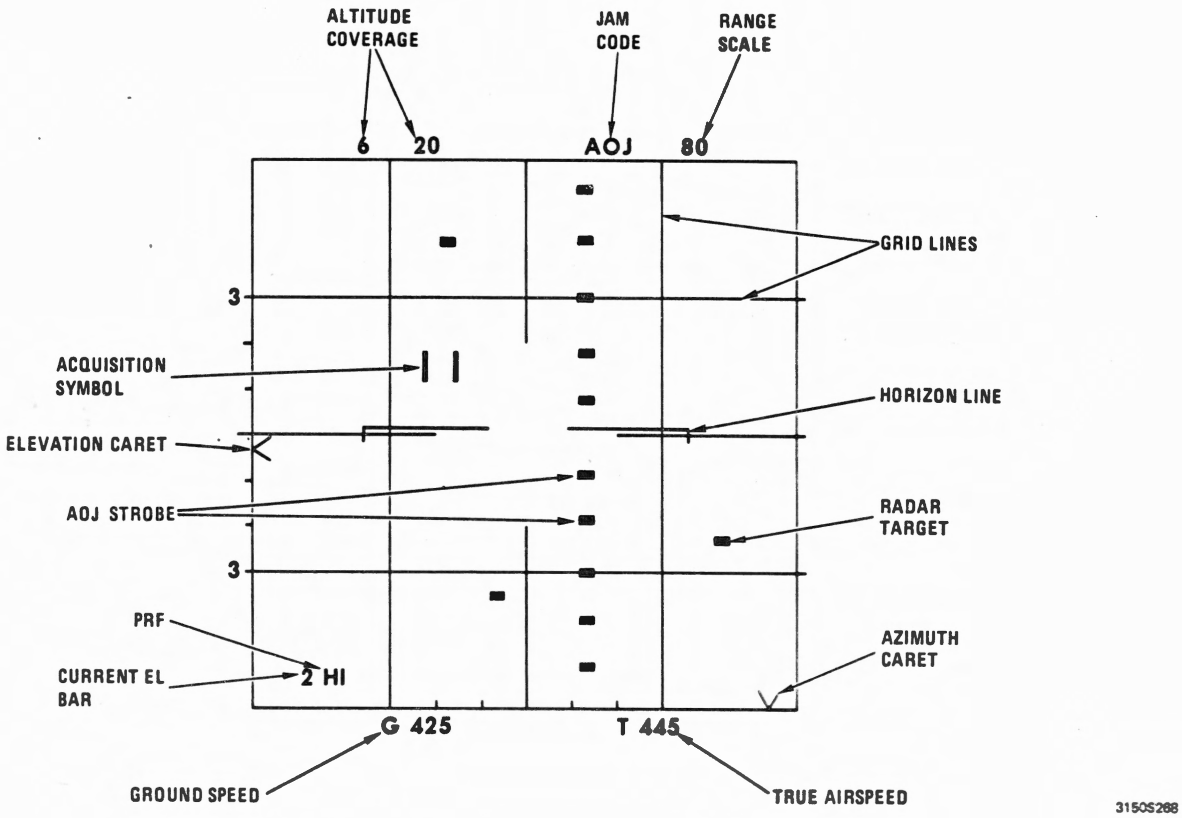
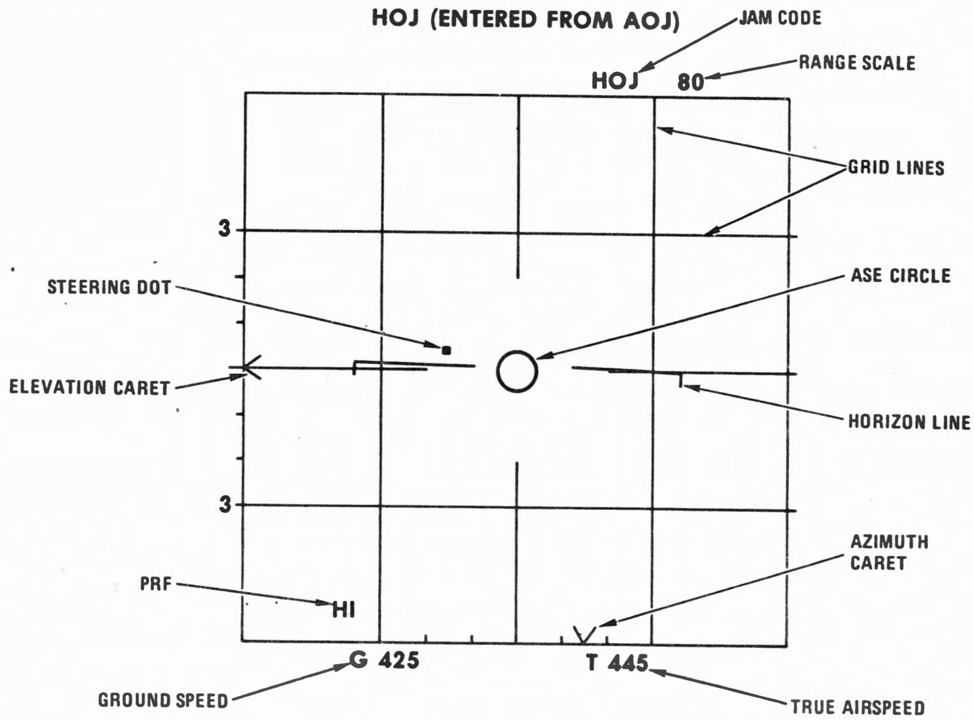


Figure 1-183. AOJ Search Display



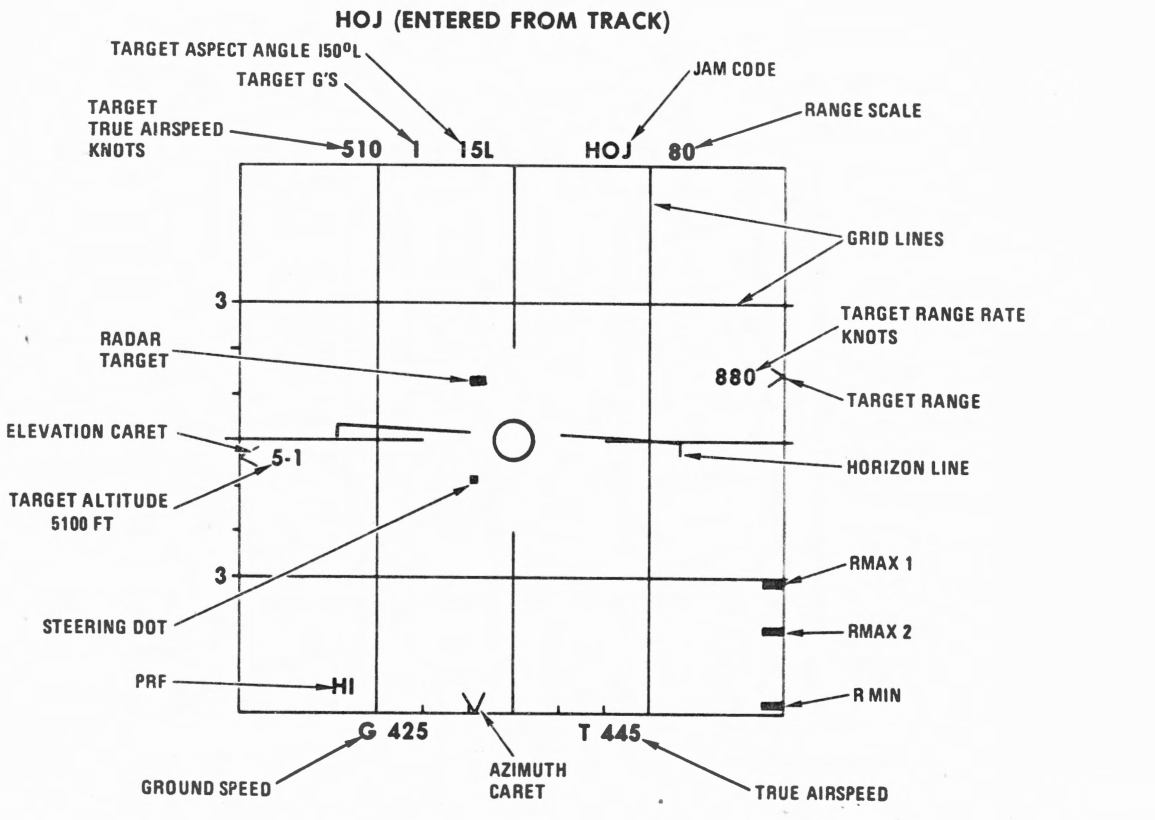


Figure 1-184. HOJ Track Displays

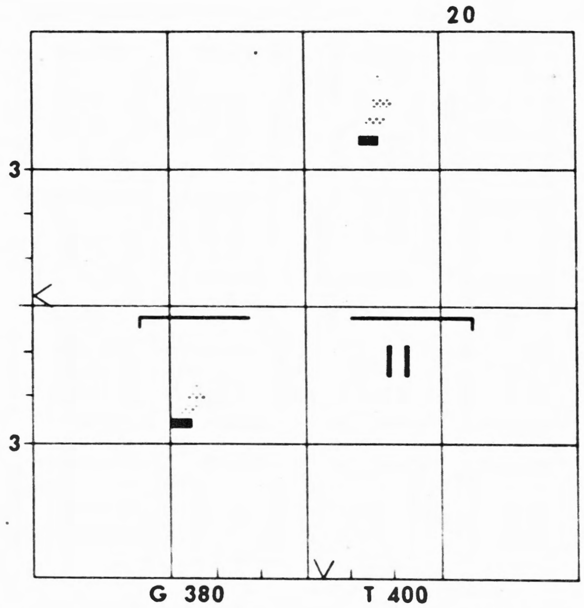


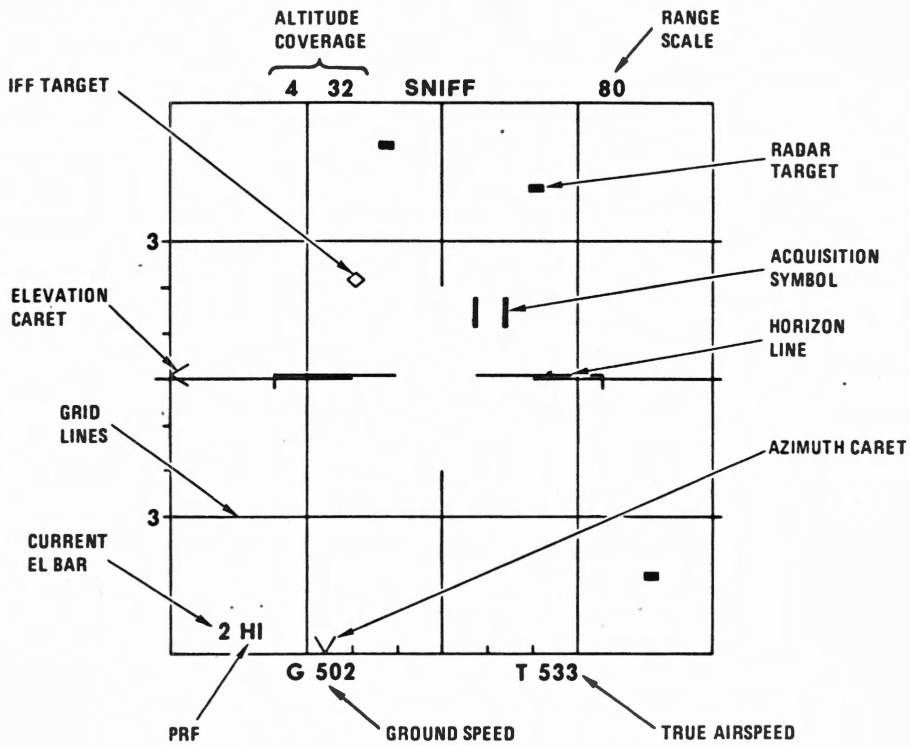
Figure 1-185. Frame Storage Display

1-82. Typical Displays in the Special Radar Modes. The sniff mode is used in conjunction with the A/A modes or the ground map mode. It is a passive/active mode that causes the simulated radar set to cease transmission at the end of the current antenna scan. The radar set then operates in a receive only mode with single bar antenna scans. Temporary active transmissions may be initiated by pressing the automatic acquisition/mode reject switch (5, figure 1-143). The ANMI displays will be the same as they are for the selected A/A mode or the ground map mode except that SNIFF will be displayed in window 1. A typical sniff display is shown in figure 1-186 (an LRS display is shown).

1-83. The manual track mode is a backup A/A mode that enables simulated missiles to be launched even though the simulated radar set has not established a target track. The ANMI displays will be the same as they are for the selected A/A mode except that MN TRK will be displayed in window 1. A typical manual track display is shown in figure 1-187 (an LRS display is shown).

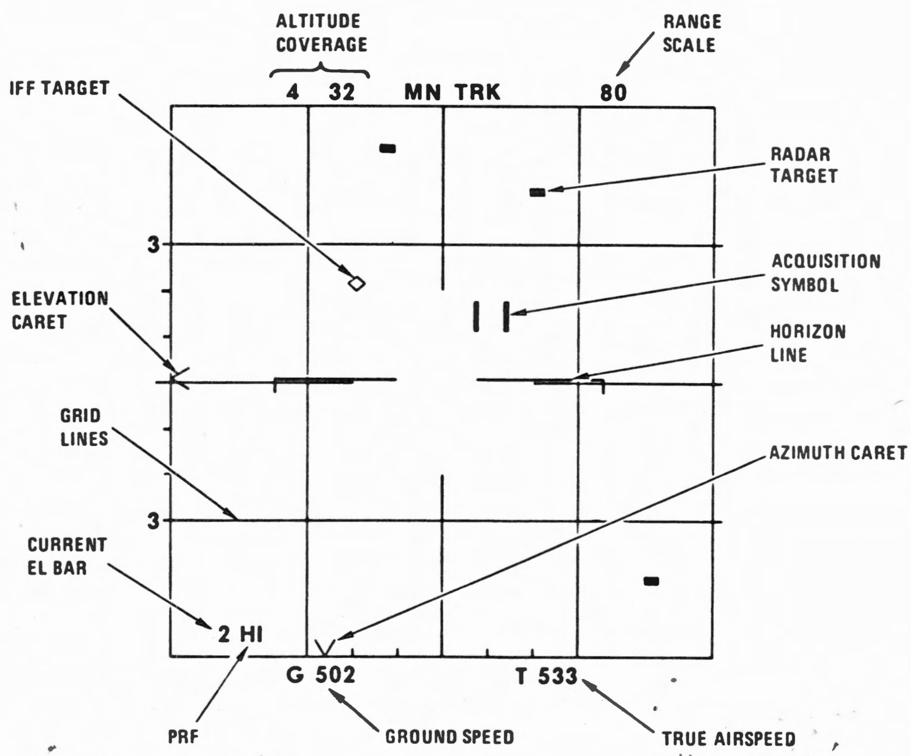
1-84. The flood mode is a last resort backup ranging mode for air-to-air gunnery. It is used when radar tracking cannot be established in the primary modes. The simulated radar set tracks for the shortest range target. The ANMI displays only the simulated aircraft true airspeed and ground speed (both in window 3), flood in window 1, and the artificial horizon. A typical flood display is shown in figure 1-188.

1-85. Typical Radar BIT Displays. During the execution of the simulated radar set BIT, a track test option is presented to the pilot. Approximately seven seconds after the BIT is initiated, TK TST will appear in the BIT window (28, figure 1-167) on the ANMI. To select the track test option, the auto acquisition/mode reject switch (5, figure 1-143) on the control stick must be pushed forward or aft within seven seconds after TK TST appears. If the track test option is not selected within seven seconds, TK TST disappears and G-TEST or TEST reappears. If the track test option is selected, search displays or map displays are presented to the pilot according to the setting of the MODE SEL switch (7, figure 1-83) on



3150S271

Figure 1-186. Sniff Display



3150S272

Figure 1-187. Manual Track Display

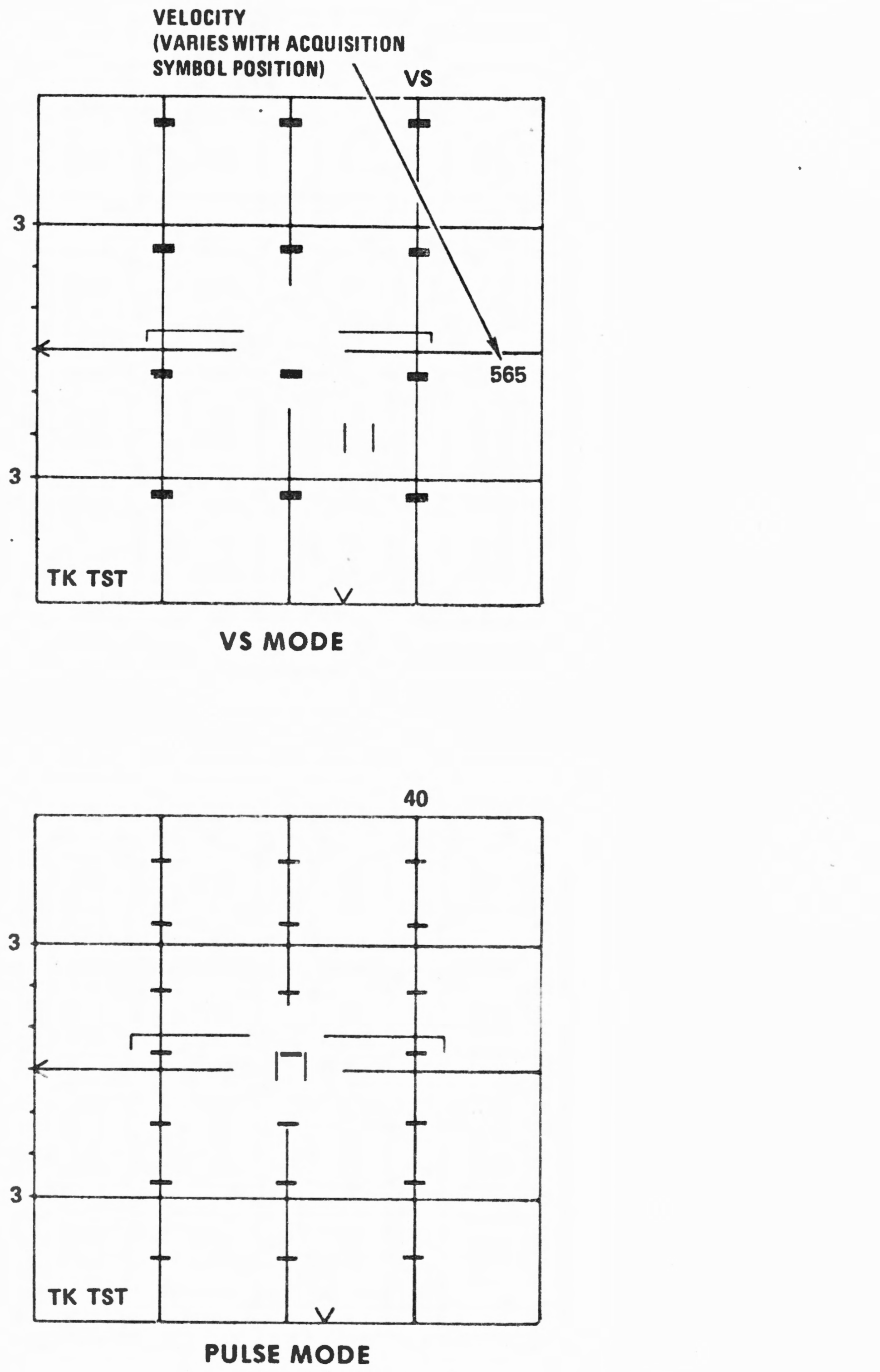


Figure 1-189. Typical Track Test Search Displays (Sheet 2)

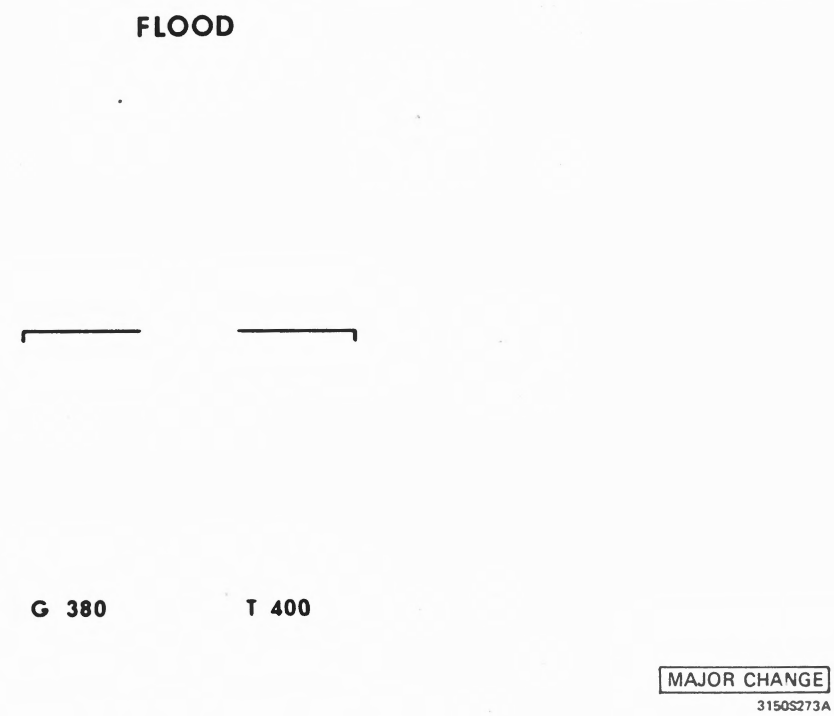
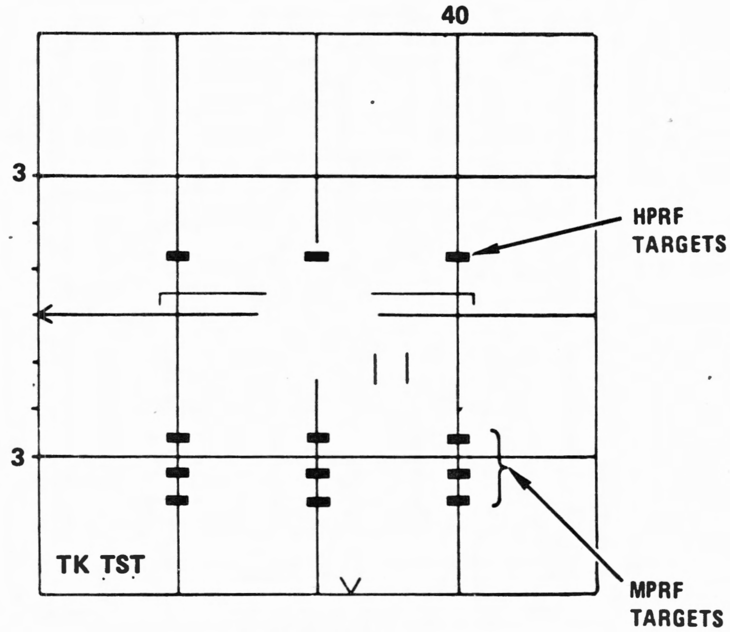


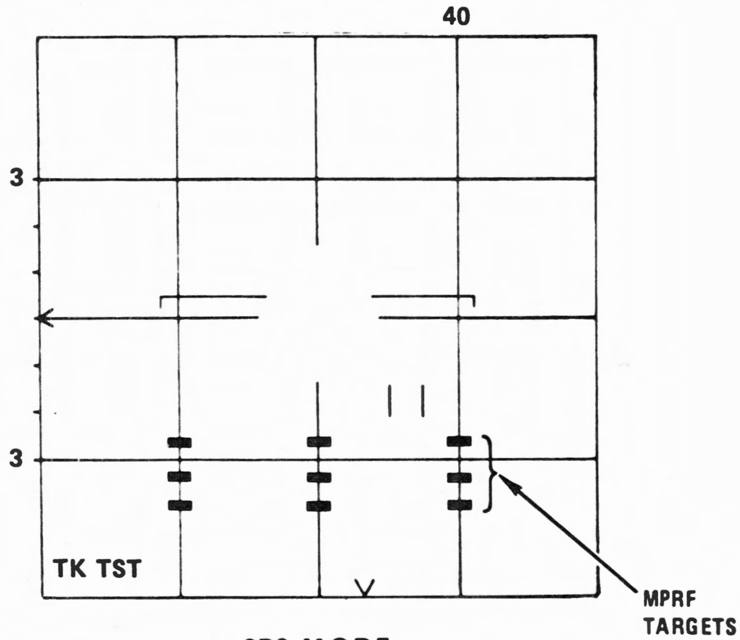
Figure 1-188. Flood Display

the radar control panel. Typical search and map displays are shown in figures 1-189 and 1-189A. The pilot can acquire and track numerous targets to test the functions of the radar system. Typical track displays are shown in figure 1-189B. The track test is terminated by reinitiation of the BIT, shutdown of the radar system, or by receipt of an AIM-7F launch initiate signal. If the BIT is reinitiated, a normal BIT continues.

1-86. All displays on the cockpit ANMI also appear on the instructor console left CRT ANMI display page (figure 1-52). For more details on simulated radar set operation and ANMI displays, refer to T.O. 1F-15A-2-25.



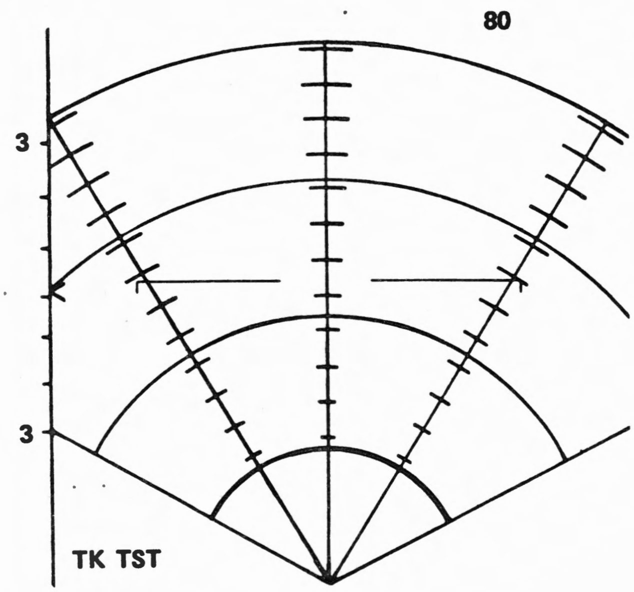
LRS MODE



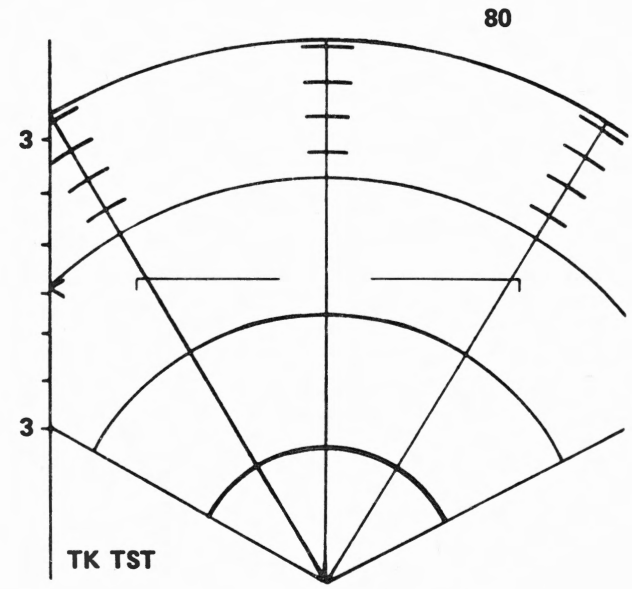
SRS MODE

3150S2902

Figure 1-189. Typical Track Test Search Displays (Sheet 1 of 2)



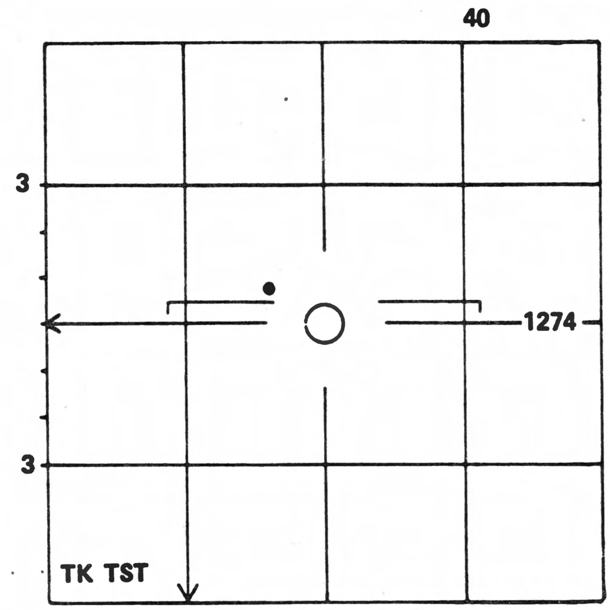
MAP MODE
(RDR CONTROL ON ANMI FULLY CW)



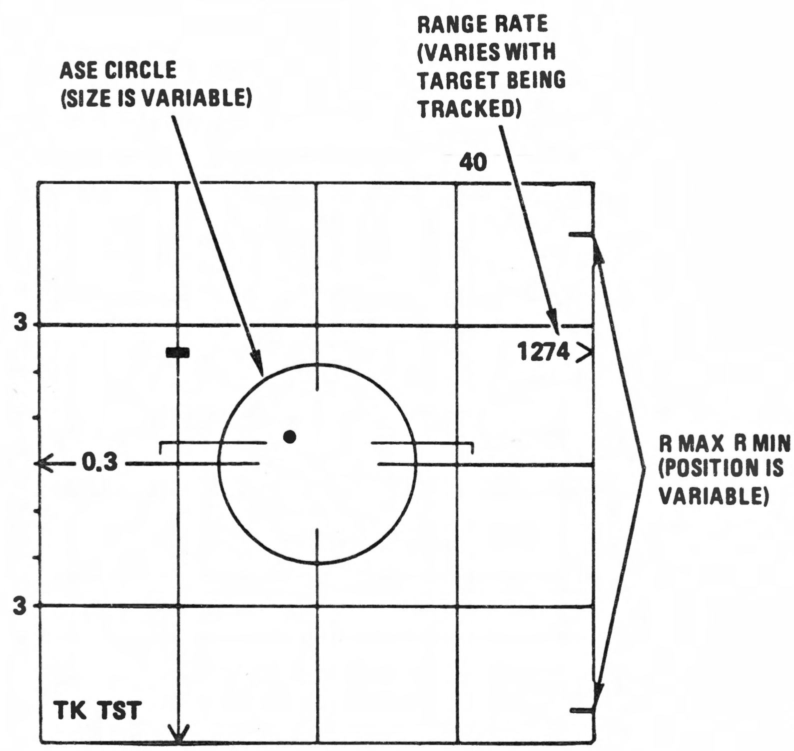
MAP MODE
(RDR CONTROL ON ANMI FULLY CCW)

3150S29C4

Figure 1-189A. Typical Track Test Map Displays



INITIAL VS TRACK DISPLAY
(ANGLE AND VELOCITY ONLY)



RANGE TRACK DISPLAY

3150S2905

Figure 1-189B. Typical Track Test Track Displays

HUD SYMBOLS

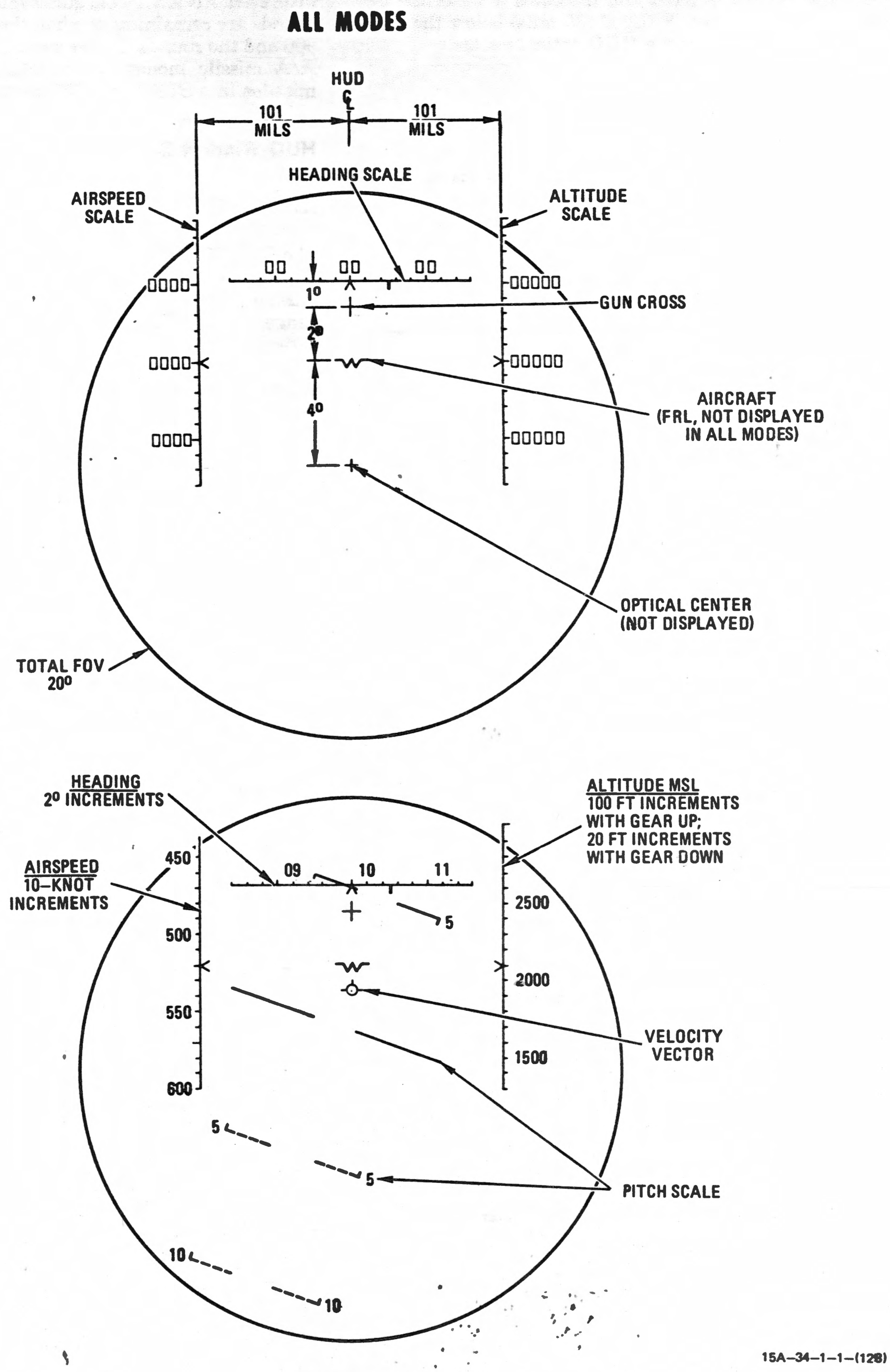
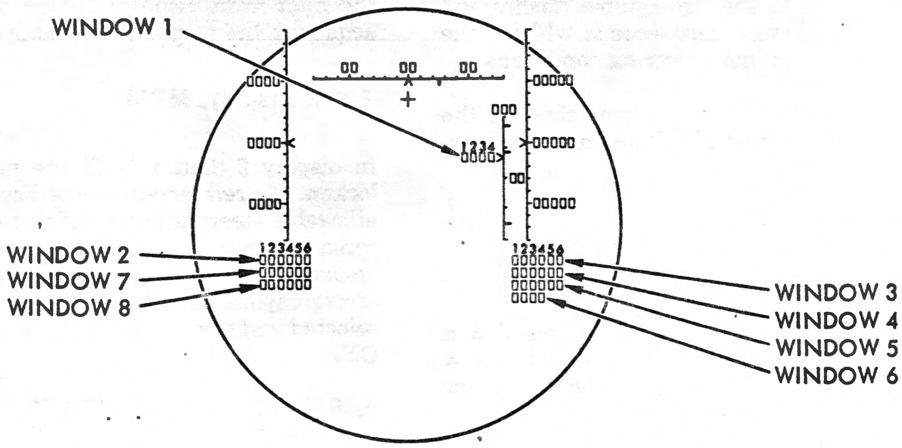


Figure 1-17

HUD WINDOW DISPLAYS

A/A, ADI, AND VI MODES



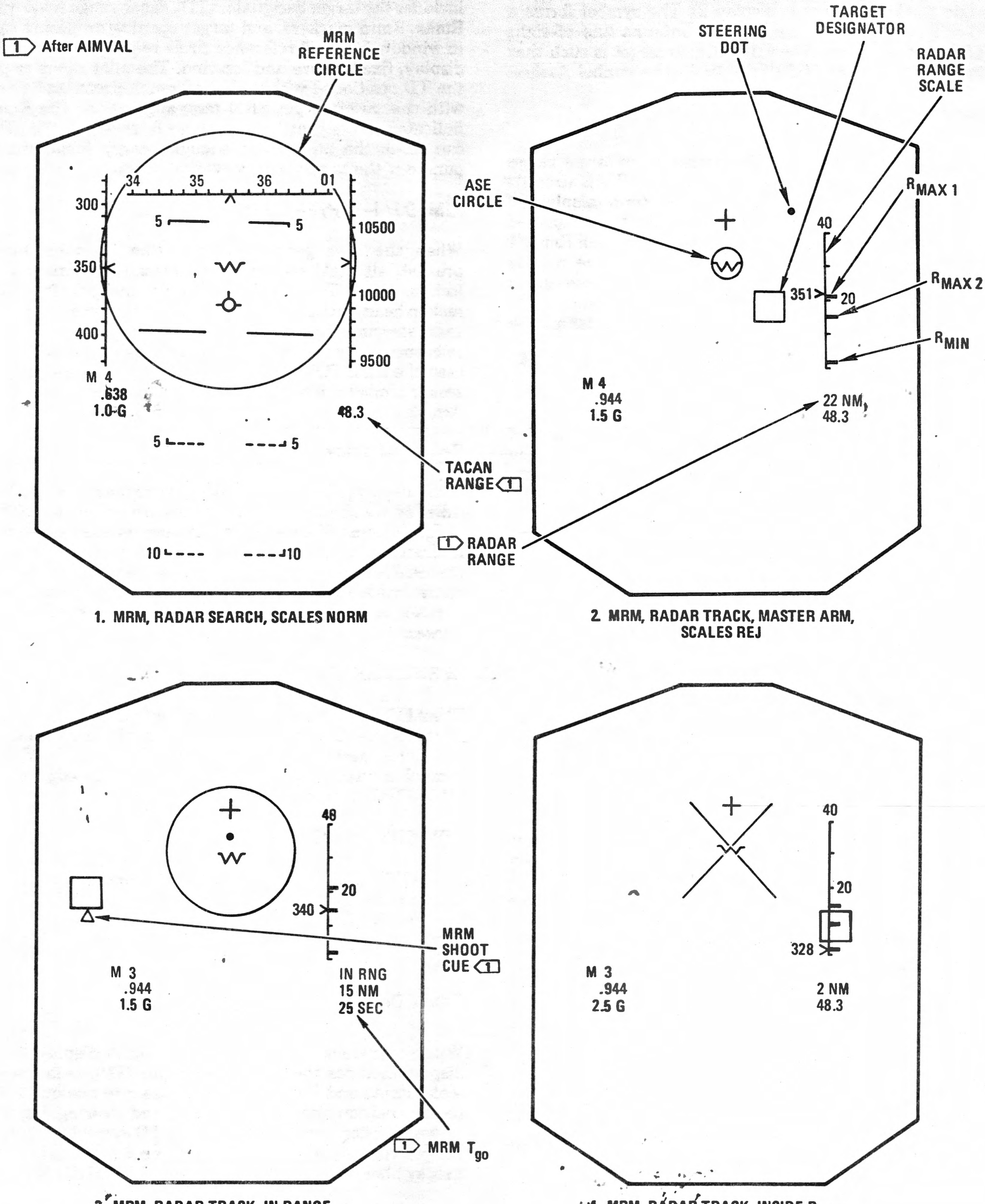
Window	Display (character positions)	Meaning
WINDOW 1 (1 2 3 4)	1 5 0	RANGE RATE, ±KTS.
WINDOW 2 (1 2 3 4 5 6)	7 0 0	ROUNDS REMAINING (XXX WITH COLD GUN)
	M 4	MRM COUNT
	S 4	SRM COUNT
	M-K R	ILS MARKER
WINDOW 3 (1 2 3 4 5 6)	I N R N G	IN RANGE (SRM, MRM)
	N O Z N	NO ZONE (SRM, MRM)
	M N T R K	MANUAL TRACK
	S N I F F	SNIFF MODE
	F L O O D	FLOOD MODE
	N A V T C N I L S - N I L S - T	ADI STEERING MODES
WINDOW 4 (1 2 3 4 5 6)	M E M	TRACK MEMORY
	J A M	RADAR JAM
	A O J	ACQUIRE ON JAM
	H O J	HOME ON JAM
[1]	8 6 N M	RADAR RANGE (A/A, VI)
WINDOW 5 (1 2 3 4 5 6)	H D A L T	HOLD ALTITUDE (MRM)
	5 0 S E C	MRM TIME-TO-GO
	1 0 5 M I N	ADI TIME-TO-GO
[1]	4 8 . 3	TACAN RANGE (A/A, VI) ADI MODE
WINDOW 6 (1 2 3 4)	C S E T	COURSE SET (ILS)
	G S U P	GLIDESLOPE UP (ILS)
	G S D N	GLIDESLOPE DOWN (ILS)
[1]	U N C	UNCAGE (SRM)
WINDOW 7 (1 2 3 4 5 6)	1 . 1 5 5	AIRCRAFT MACH
WINDOW 8 (1 2 3 4 5 6)	T M 1 . 5	TARGET MACH
	2 . 5 G	AIRCRAFT G

[1] AFTER AIMVAL

15A-34-1-1-(72)F

Figure 1-18

HUD DISPLAYS, MRM STEERING



1. MRM, RADAR SEARCH, SCALES NORM

2. MRM, RADAR TRACK, MASTER ARM, SCALES REJ

3. MRM, RADAR TRACK, IN RANGE, MASTER ARM, T_{go}, SCALES REJ

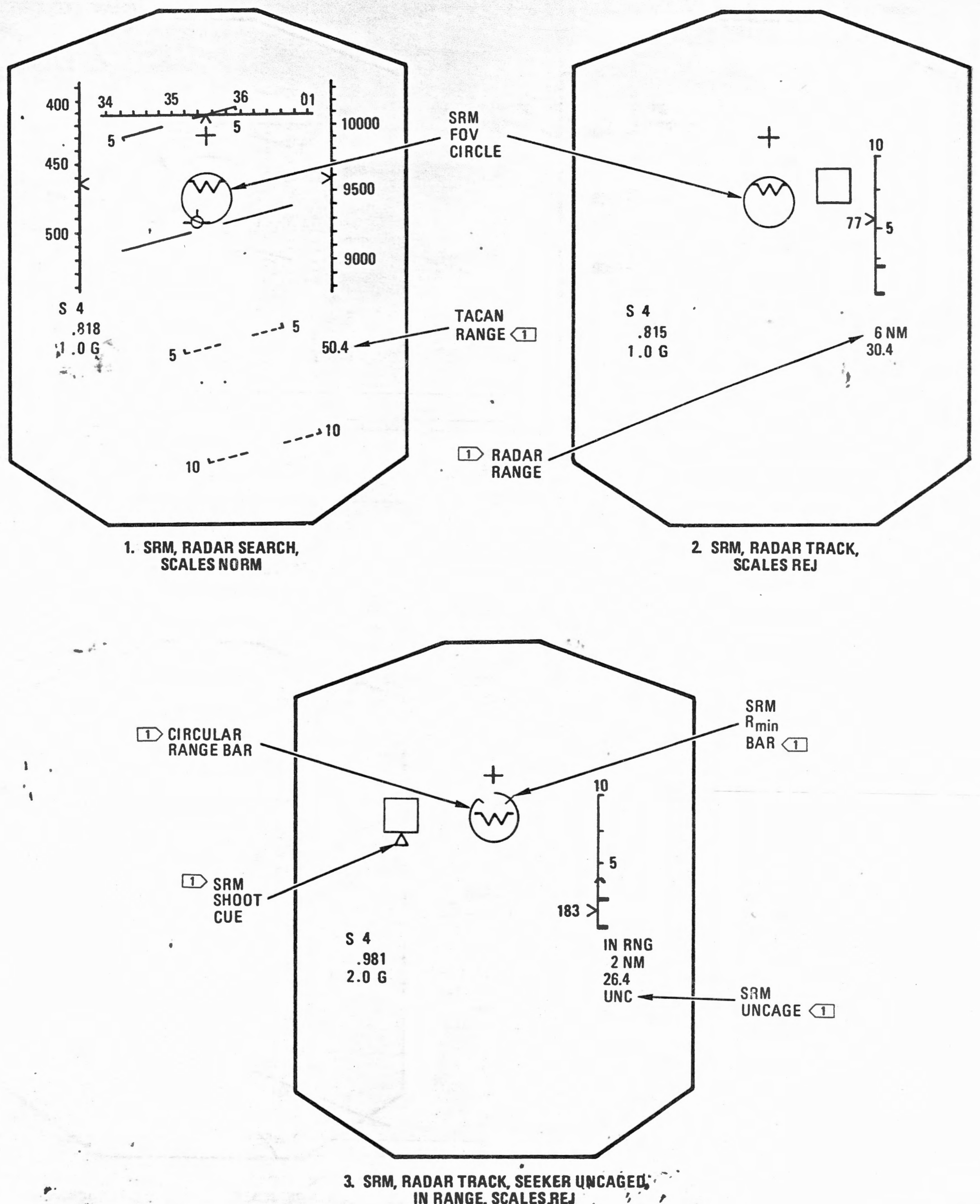
4. MRM, RADAR TRACK, INSIDE R_{MIN}, MASTER ARM, SCALES REJ

15A–34–1–1–(83)D

Figure 1-19

HUD DISPLAYS, SRM STEERING

AIM-9J/J-1/P/P-1 DISPLAYS



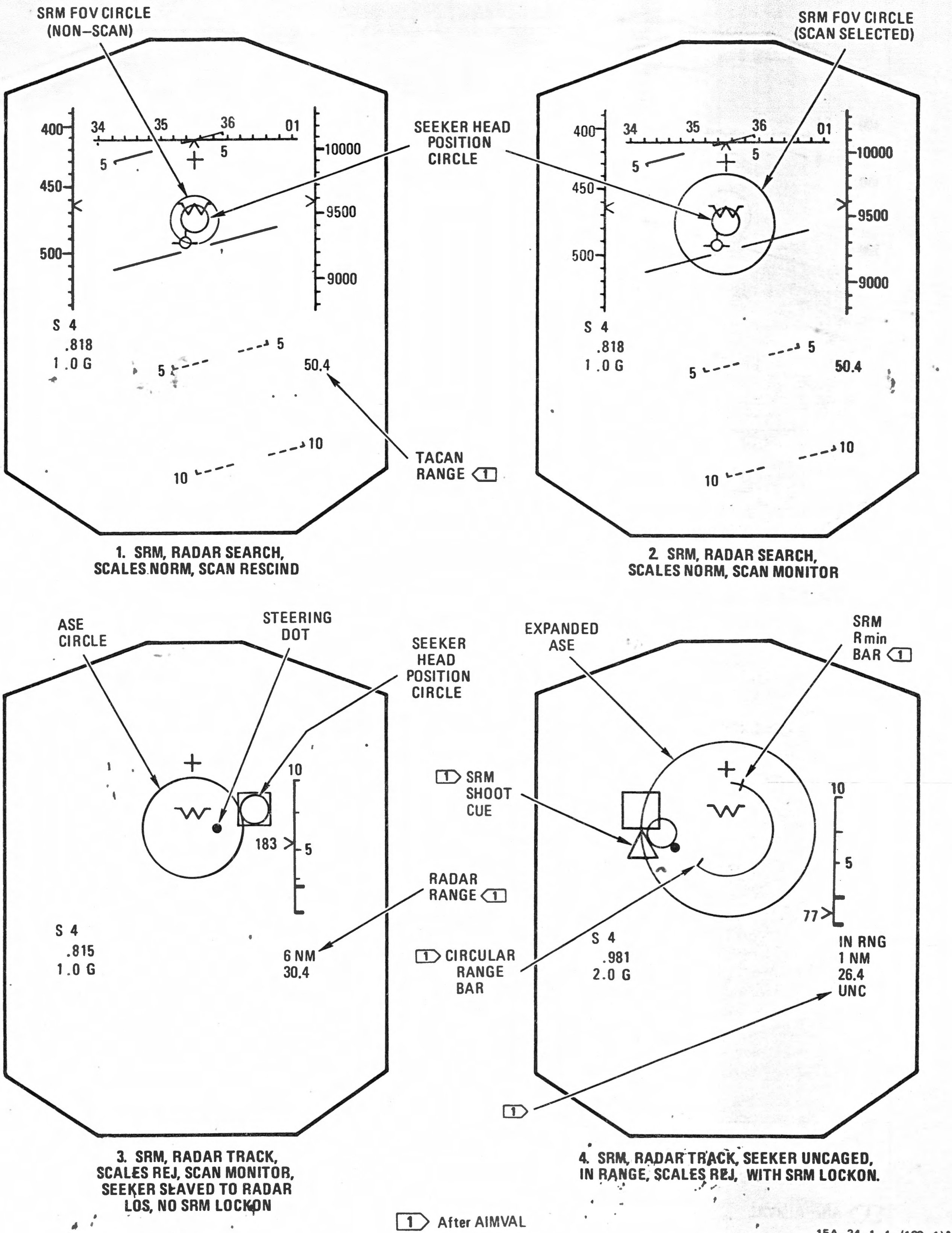
1 After AIMVAL

15A-34-1-1-(91)

Figure 1-20

HUD DISPLAYS, SRM STEERING

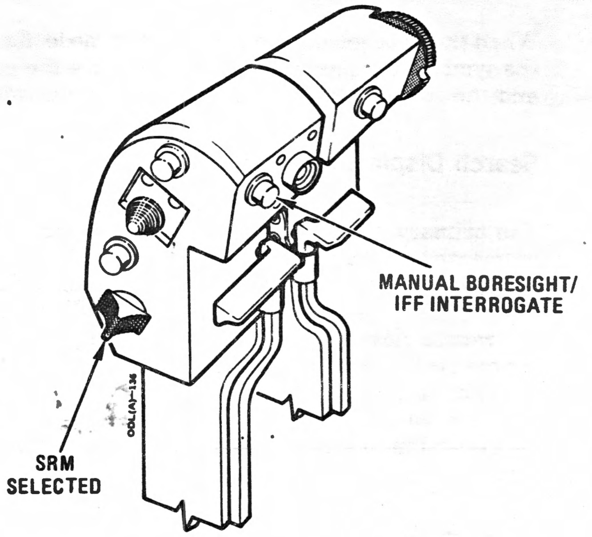
AIM-9L DISPLAYS

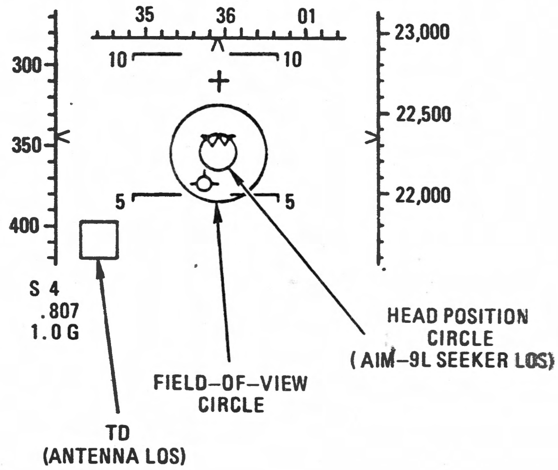


1 After AIMVAL

15A-34-1-1-(169-1)A

Figure 1-20A





INHIBITED AIM–9L SYMBOLS

RANGE SCALE

RANGE CARET & RANGE RATE

R_{max} R_{min}

IN RANGE/NO ZONE

SHOOT CUE

RANGE BAR

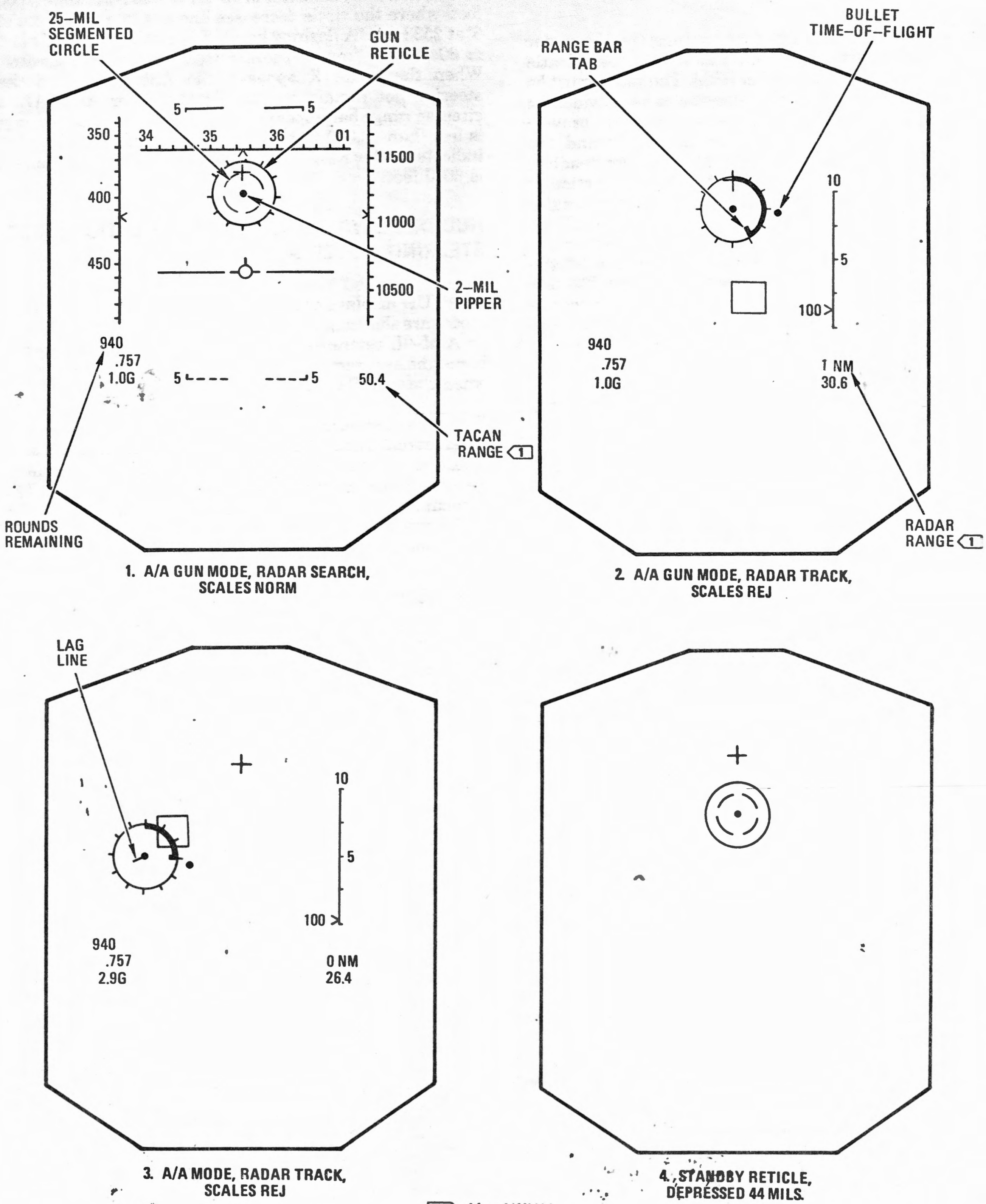
[1] **5. AIM-9L MANUAL BORESIGHT DISPLAY RADAR TRACK, SCALES NORM, SCAN MONITOR, IFF BUTTON DEPRESSED, SEEKER CAGED, NO SRM LOCKON.**

[1] After AIMVAL

15A–34–1–1–(169–2)

Figure 1-20A (Sheet 2)

HUD DISPLAYS, GUN MODE STEERING

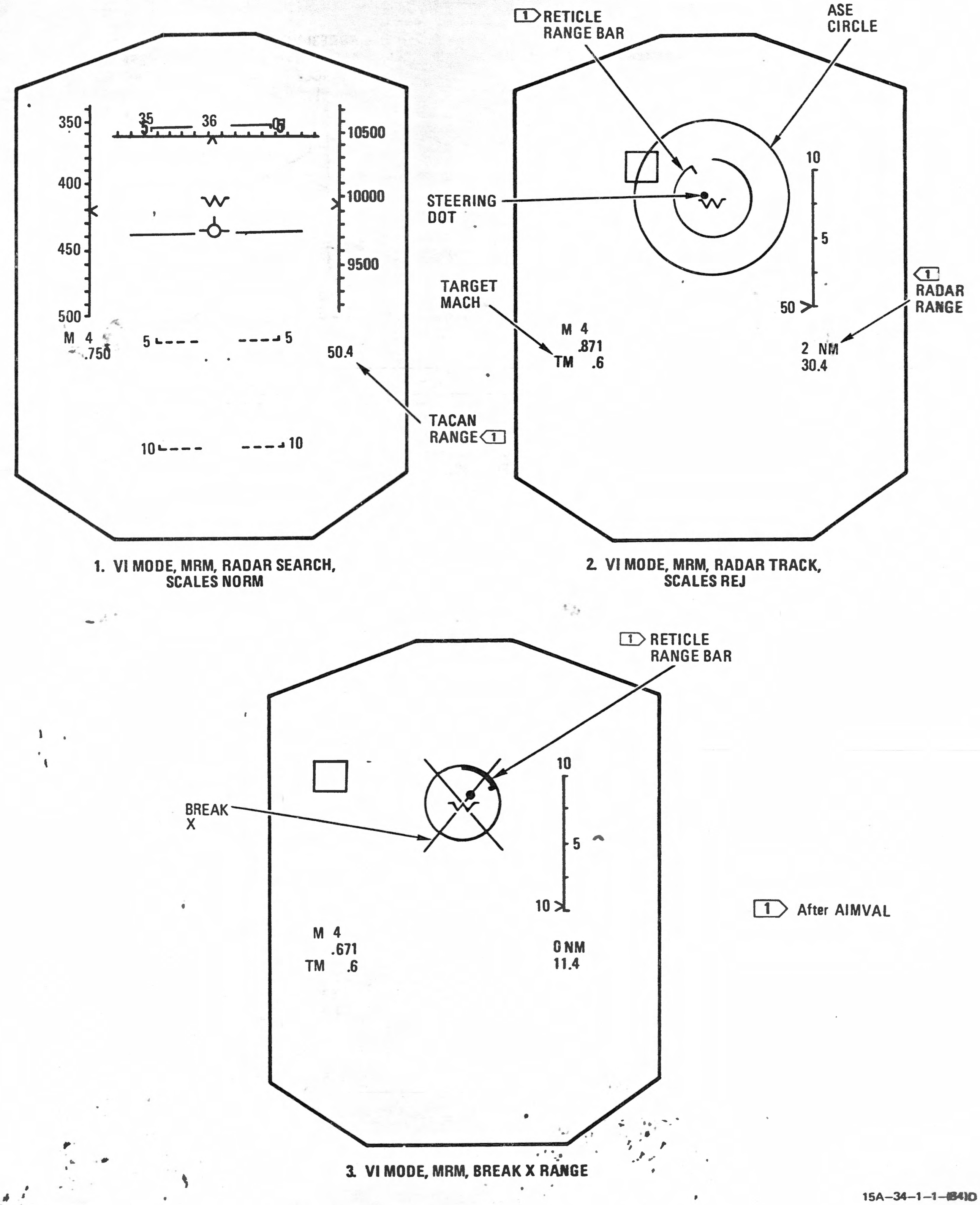


1 After AIMVAL

15A-34-1-1-(82)C

Figure 1-21

HUD DISPLAYS, VIS-IDENT STEERING



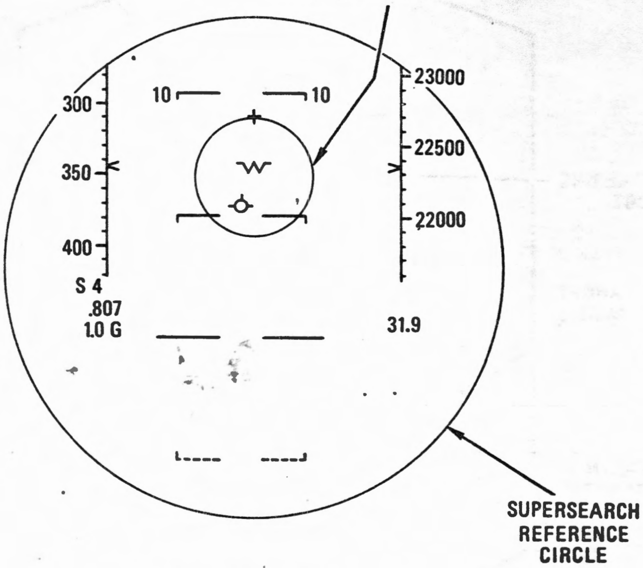
1. VI MODE, MRM, RADAR SEARCH, SCALES NORM

2. VI MODE, MRM, RADAR TRACK, SCALES REJ

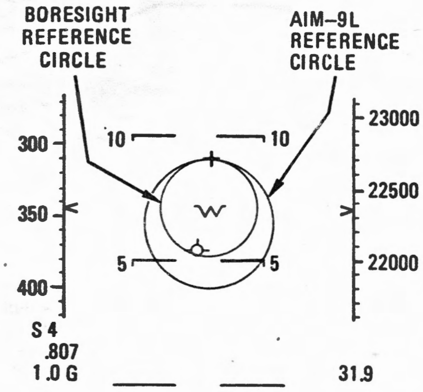
3. VI MODE, MRM, BREAK X RANGE

Figure 1-23.

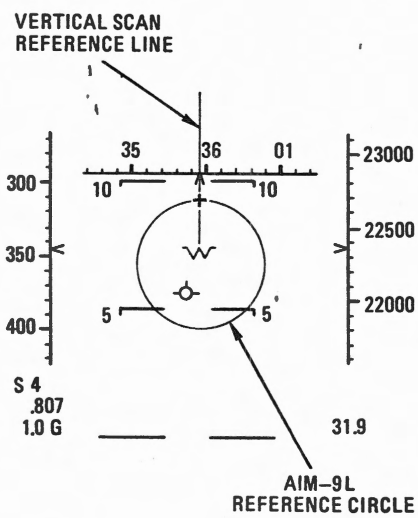
HUD DISPLAYS, AUTOMATIC ACQUISITION MODES
(AIMVAL AIRCRAFT)



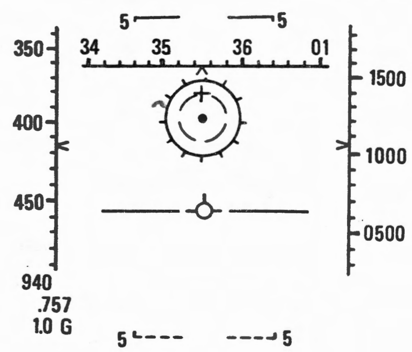
1. SUPERSEARCH (SS),
SRM SELECTED.



2. BORESIGHT (BST),
SRM SELECTED.



3. VERTICAL SCAN,
SRM SELECTED.



4. AUTO GUN SCAN,
GUN SELECTED.

15A-34-1-1-(167)

Figure 1-23A

HUD SYMBOLOGY SUMMARY

MODE / SYMBOL	A/A MODE				VI	A/G MODE				ADI MODE				ALL MODES	
	MRM (AIM-7F)	SRM (AIM-9J/J-1/P/P-1)	GUN	SRM (AIM-9L)	VIS-IDENT	AUTO	CDIP	DIRECT/MANUAL	GUIDED WEAPON (EO)	NAV	TACAN	ILS-NAV	ILS-TCN	CC NO-GO	SYMBOLS REJECT
WINDOW 1:															
RANGE RATE	X	X	X	X	X										
WINDOW 2:															
ROUNDS REMAINING			X												
MISSILE COUNT	X	X		X											
ILS MARKER												X	X		
WINDOW 3:															
IN RANGE	X	X		X											
NO ZONE	X	X		X											
RADAR SPECIAL MODES	X	X	X	X	X										
NAV										X					
TCN											X				
ILS–N												X			
ILS–T													X		
WINDOW 4:															
MEM	X	X	X	X	X										
JAM CODES	X	X	X	X	X										
NAV DEST., MK. TGT						X	X	X	X	X		X			
RADAR RANGE	⊙	⊙	⊙	⊙	⊙										
WINDOW 5:															
HOLD ALT	X														
A/G TIME–TO–GO						X	X								
ADI TIME–TO–GO										X	X	X	X		
MISSILE TIME–TO–GO	X														
TACAN RANGE	⊙	⊙	⊙	⊙	⊙										
ADI RANGE										⊙	⊙	⊙	⊙		
WINDOW 6:															
COURSE SET												X	X		
GLIDESLOPE WARNING												X	X		
UNC		⊙		⊙											
WINDOW 7:															
MACH NO.	X	X	X	X	X										

⊙ AFTER AIMVAL

15A–34–1–1–(130–1)F

Figure 1-24 (Sheet 1 of 2)

HUD SYMBOLOGY SUMMARY (*Continued*)

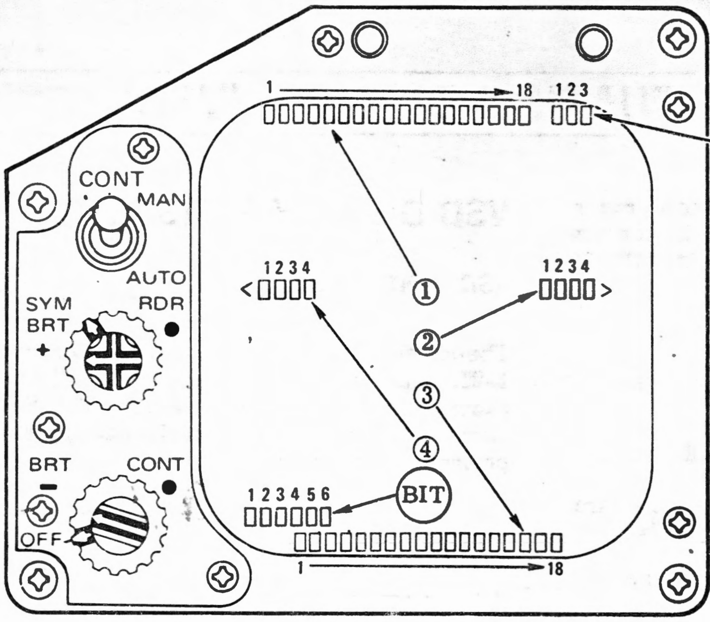
SYMBOL \ MODE	A/A MODE				VI	A/G MODE				ADI MODE				ALL MODES	
	MRM (AIM-7F)	SRM (AIM-9J/J-1/P/P-1)	GUN	SRM (AIM-9L)	VIS-IDENT	AUTO	CDIP	DIRECT/MANUAL	GUIDED WEAPON (EO)	NAV	TACAN	ILS-NAV	ILS-TCN	CC NO-GO	SYMBOLS REJECT
WINDOW 8:															
TGT MACH					X										
AIRCRAFT G	X	X	X	X		X	X	X	X	X	X	X	X		
SHOOT CUE	⊙	⊙		⊙											
PITCH STEERING												X	X		
BANK STEERING										X	X	X	X		
AIRCRAFT SYMBOL	X	X		X	X					X	X	X	X	X	
VELOCITY VECTOR	X	X	X	X	X	X	X	X	X	X	X	X	X		Ⓧ
AZIMUTH STEERING LINE						X	X								
DISPLAYED IMPACT LINE							X								
ALTITUDE SCALE	X	X	X	X	X	X	X	X	X	X	X	X	X		X
AIRSPEED SCALE	X	X	X	X	X	X	X	X	X	X	X	X	X		X
HEADING SCALE	X	X	X	X	X	X	X	X	X	X	X	X	X		X
COMMAND HEADING						X	X	X	X						
AOA SCALE										X	X	X	X		X
PITCH SCALE	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
RANGE SCALE	X	X	X	X	X										
GUN CROSS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	
R_{MIN}, $R_{MAX\ 1}$	X	X		X											
$R_{MAX\ 2}$	X														
ASE CIRCLE	X	X		X	X										
RETICLE RANGE BAR		⊙	X	⊙	⊙	X	X	X	X					X	
A/A RETICLE			X											X	
LAG LINE			X												
A/G RETICLE						X	X	X	X						
BULLET TIME-OF-FLIGHT			X												
STEERING DOT	X			X	X										
RELEASE CUE						X	X								
PULL-UP CUE						X	X								
A/A TGT DESIGNATOR	X	X	X	X	X										
A/G DESIGNATOR						X	X	X	X						
BREAKAWAY CUE	X	X		X	X										
FOV/REF CIRCLE	X	X		X											
SRM SEEKER POSITION		X		X											
VERT SCAN LINE	⊙	⊙	⊙	⊙	⊙										
SUPER SEARCH CIRCLE	X	X	X	X	X										

Ⓧ REJECT IN A/A MODE ONLY
⊙ AFTER AIMVAL

15A-34-1-1-(130-2)F

Figure 1-24 (Sheet 2)

VSD CONTROLS/WINDOW DISPLAYS



Range scale window (1 2 3):

160
80
40
20
10 — Radar Range Selected

VS — Velocity Search

WINDOW① (1 5 10 14 18) MEM — Track Memory

JAM
AOJ
HOJ — Radar Jam Codes

(10 14) MN TK
SNIFF
FLOOD — Radar Special Modes

(1 7) 10 28 — Min/Max Scan Altitude (MSL)

(1 5) 1075 13. — Target Speed/Accel.

(5 10) 10R
L
H
T — Aspect Angle

A/A Target Track Data

(1 5) STBY
TUNE — Radar Operating Cues

WINDOW② (1 5) 1300 — Range Rate (A/A or VI Track) Acq. Symbol velocity, VS Mode (After AIMVAL)

1 Predicted MRM Time-of-flight (After AIMVAL)

WINDOW③ (1 5 10 14 18) G1000 T1000 — Ground Speed (G) True Air - Speed (T)

(7 12)
29 SEC — MRM Time-to-go
HD ALT — Hold Altitude
IN RNG — In Range 1
NO ZN — No Zone

WINDOW④ (1 4) 15-5 — Target Alt. (MSL)

BIT WINDOW (1 6) 4 — Current Bar

HI
MED
LO — Radar PRF

RF NG — Radar Transmitter Power Low
FS2 — Frame Store Selected (BCN modes only)
CHAN 3 — Channel Selected (Passive Sniff Mode only)
I — AAI Interrogate
RDR HOT — Insufficient Cooling Air To Radar Data Processor

15A-34-1-1-(92)G

Figure 1-25

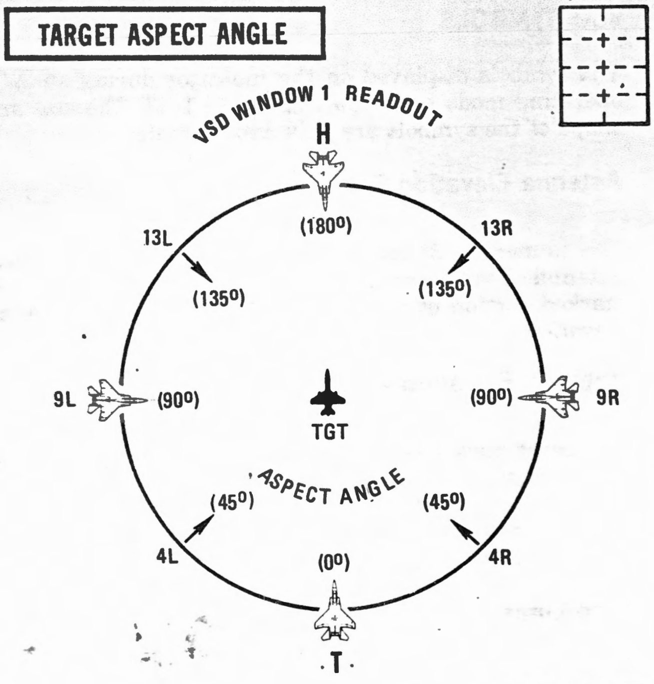


Figure 1-26

RADAR OPERATING CUES

STBY	Displayed when STBY is selected on the radar power knob. If the radar power knob is moved from OFF directly to OPR, STBY is displayed for 3 minutes.
TUNE	Displayed when radar OPR is first selected (after 3-minute STBY). The cue remains ON until all missiles TUNE or for a maximum of 2 minutes. Normally, the missiles tune in about 5 seconds; the ACP MRM status windows show STBY and the TUNE cue goes OFF. If a missile does not tune, it is automatically dropped from the firing order. If no missiles are aboard, the cue appears for 5 seconds, then goes OFF.

RADAR SPECIAL MODES

When the radar is operating in a special mode, the operating mode is announced: FLOOD, SNIFF, or MN TK (manual track mode).

VSD Window 2

Window 2 displays the opening or closing rate (KTS) between the aircraft and the target when the radar is in A/A or VI range track.

After AIMVAL, a velocity readout is displayed in window 2 in the radar VS mode. The velocity readout replaces the range rate readout presented during the manual track mode with VS selected. The readout is the velocity position of the acquisition symbol on the VSD.

VSD Window 3

GROUND SPEED/TRUE AIRSPEED

In window 3, the ground speed and true airspeed readouts are displayed in any operational mode except EO.

MRM TIME-TO-GO (Tgo)

In AIMVAL aircraft, Tgo is an MRM time of flight cue displayed when target range is between Rmax 1 and Rmin. At launch (in all aircraft), the cue flashes and begins countdown to zero (missile impact) for the last missile fired. (Refer to HUD window 5.)

HOLD ALTITUDE (HD ALT)

In radar track, this cue indicates that the MRM attack geometry requires the pilot to maintain present altitude. A snap-up maneuver is flown when the cue goes OFF.

IN RANGE (IN RNG)

After AIMVAL, the MRM IN RNG cue is replaced by predicted AIM-7F Tgo. IN RNG is displayed in the SRM mode when range is within Rmax and Rmin.

NO ZONE (NO ZN)

In radar track, this cue appears when Rmax is less than Rmin. The cue may also appear as a result of erroneous target track information or erratic antenna motion. Refer to Aircraft Weapons, AIM-7F, TO 1F-15A-34-1-1-1.

VSD Window 4

In radar track, the cue indicated is target altitude (MSL) in thousands and hundreds of feet (15-5 means 15,500 feet MSL).

VSD BIT Window

BAR SCAN

In any A/A search mode, the current bar in the EL scan pattern is indicated by a single digit readout (1 thru 8).

RADAR PRF (HI, MED, LO)

In any A/A search or track mode, the transmitted radar PRF is indicated.

RF NO-GO (RF NG)

This cue is displayed any time the radar transmitter power is below nominal in a normal transmitting period.

FRAME STORE SELECT

In beacon modes, the frame store number selected on the radar panel is displayed as a single digit (1 through 7) preceded by FS.

CHANNEL SELECT

During the passive portion of the radar SNIFF mode, the channel presently selected on the radar panel is displayed by a single character (1 through 6 or A) preceded by CHAN (figure 1–25).

AAI INTERROGATE

When the pilot initiates an AAI challenge (in a radar compatible mode), the symbol I appears in the BIT window during the challenge period.

RADAR HOT (RDR HOT)

On aircraft with 24K radar data processors, a RDR HOT indication is flashed in the VSD BIT window when insufficient cooling is being provided to the radar data processor. The radar overheat protection sensor will automatically shut down radar power if over temperature or low cooling air flow occurs during ground operation.

VSD SYMBOLS

The symbols displayed on the indicator during an A/A operating mode are shown in figure 1–27. The size and shape of the symbols are only approximate.

Antenna Elevation Scale

The numerals (3) on the scale indicate $\pm 30°$ of radar antenna elevation angle. An additional 30 exists along the un marked portion of the scale for a total of $\pm 60°$ antenna elevation.

Antenna Elevation Caret

The caret moves vertically along the antenna elevation scale. In search, the caret indicates antenna elevation angle with respect to the horizon. In track, the caret indicates the elevation angle of the target with respect to the horizon.

Grid Lines

The grid lines are range (or velocity) and azimuth references. The vertical spacing between horizontal lines represents one–quarter of the selected range. In velocity search (VS), each space represents 750 fps (approximately 450 knots) of target relative ground speed. The horizontal spacing between each vertical grid line represents 30° in azimuth.

VSD SYMBOLS, A/A MODES

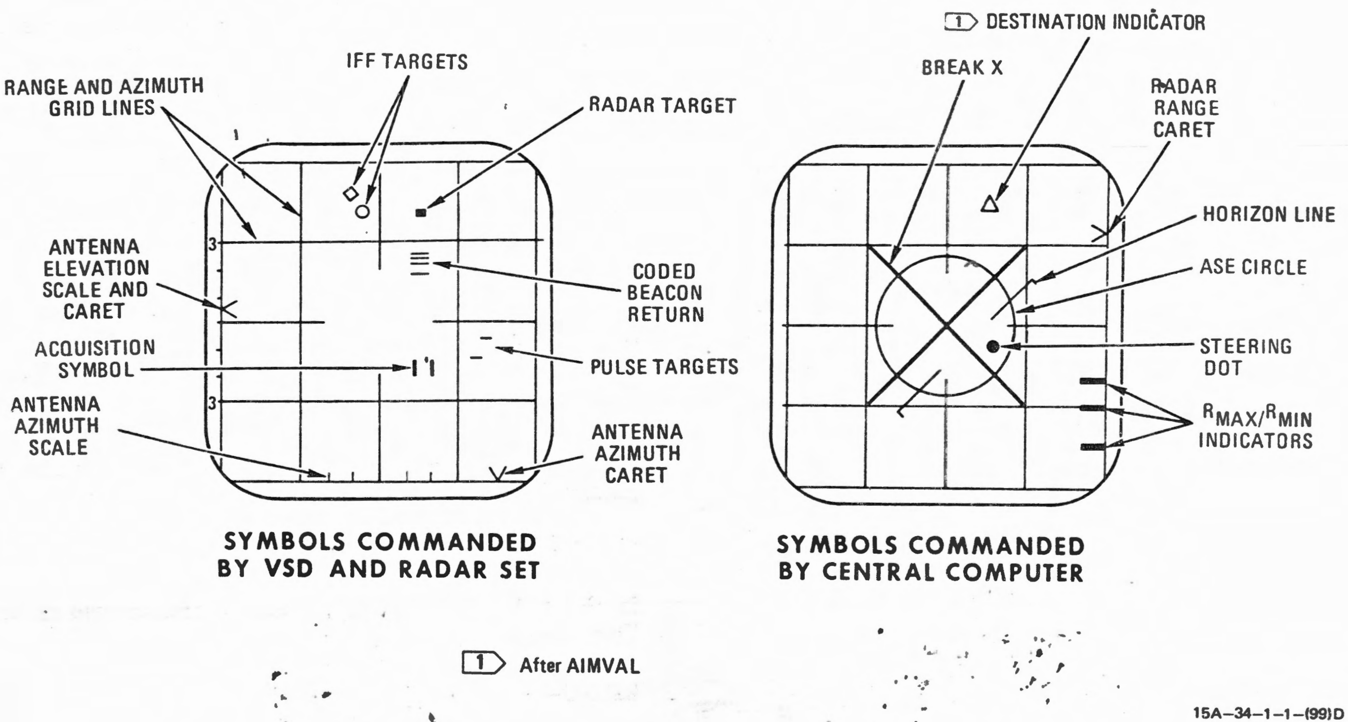


Figure 1–27

VSD SYMBOLOGY SUMMARY

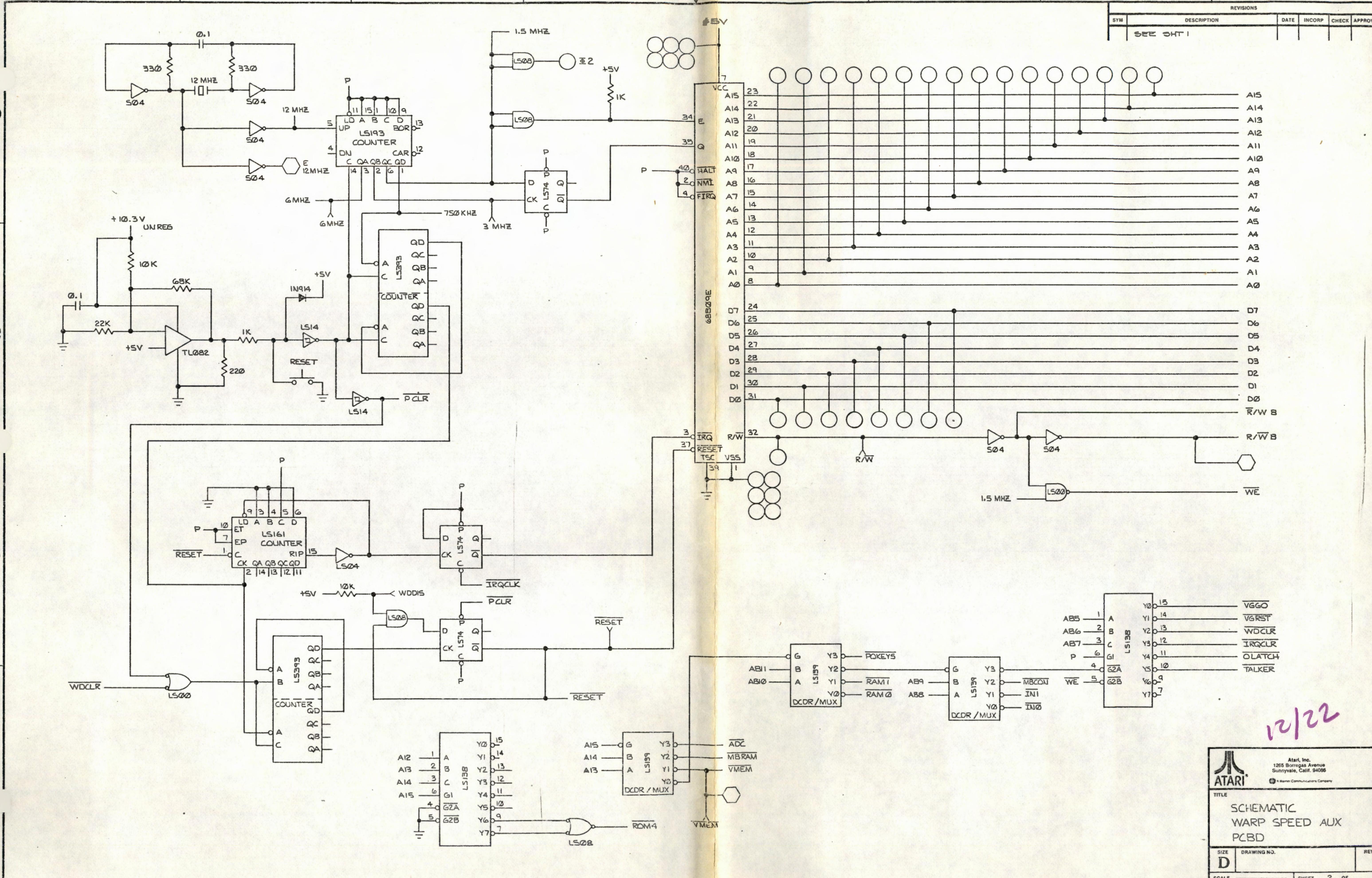
SYMBOL \ MODE	A/A MODE: MRM	A/A MODE: SRM	A/A MODE: GUN	VI: VIS, IDENT.	A/G MODE: AUTO	A/G MODE: CDIP	A/G MODE: DIRECT/MANUAL	A/G MODE: GUIDED WPN (EO)	ADI MODE: NAV	ADI MODE: TACAN	ADI MODE: ILS-NAV	ADI MODE: ILS-TCN	ALL MODES: CC NO-GO
WINDOW 1:													
TRK MEM	X	X	X	X					X	X	X	X	
JAM CODES	X	X	X	X					X	X	X	X	
RADAR SPECIAL MODES	X	X	X	X					X	X	X	X	
RADAR STBY	X	X	X	X					X	X	X	X	
MISSILE TUNE	X	X	X	X	X	X	X	X	X	X	X	X	
EO UNCAGED								X					
ALTITUDE COVERAGE	X	X		X					X	X	X	X	
TARGET TRACK DATA	X	X	(•)	X					X	X	X	X	
WINDOW 2:													
RANGE RATE	X	X	X	X					X	X	X	X	
WINDOW 3:													
GROUND SPEED	X	X	X	X	X	X	X		X	X	X	X	
TRUE AIRSPEED	X	X	X	X	X	X	X		X	X	X	X	
MISSILE TIME-TO-GO	X								X	X	X	X	
A/G TIME-TO-GO					X	X							
HOLD ALT	X								X	X	X	X	
IN RNG	(X)	X							X	X	X	X	
NO ZONE	X	X							X	X	X	X	
WINDOW 4:													
TARGET ALT	X	X	X	X					X	X	X	X	
BIT WINDOW													
EL. BAR/PRF	X	X	X	X					X	X	X	X	X
DEST INDICATOR	(•)	(•)	(•)	(•)									
TARGET/IFF SYMBOLS	X	X	X	X					X	X	X	X	X
ACQUISITION SYMBOL	X	X	X	X					X	X	X	X	X
RADAR A/A MODE VIDEO	X	X	X	X					X	X	X	X	X
RADAR A/G MODE VIDEO	X	X	X	X	X	X	X		X	X	X	X	X
EO VIDEO								X					
R_{MIN}, $R_{MAX\ 1}$	X	X							X	X	X	X	
$R_{MAX\ 2}$	X								X	X	X	X	
BREAKAWAY CUE	X	X		X					X	X	X	X	
RANGE TO TARGET	X	X	X	X					X	X	X	X	
ASE CIRCLE	X	X	X	X					X	X	X	X	
STEERING DOT	X	X	X	X					X	X	X	X	
CURSOR	X	X	X	X	X	X	X		X	X	X	X	
ARTIFICIAL HORIZON	X	X	X	X	X	X	X		X	X	X	X	
RANGE/VELOCITY SCALE	X	X	X	X	X	X	X		X	X	X	X	X
EL SCALE	X	X	X	X	X	X	X		X	X	X	X	X
AZ SCALE	X	X	X	X					X	X	X	X	X

(X) REMOVED AFTER AIMVAL
(•) ADDED AFTER AIMVAL

15A-34-1-1-(129)F

Figure 1-28

Tab - “Schematics”



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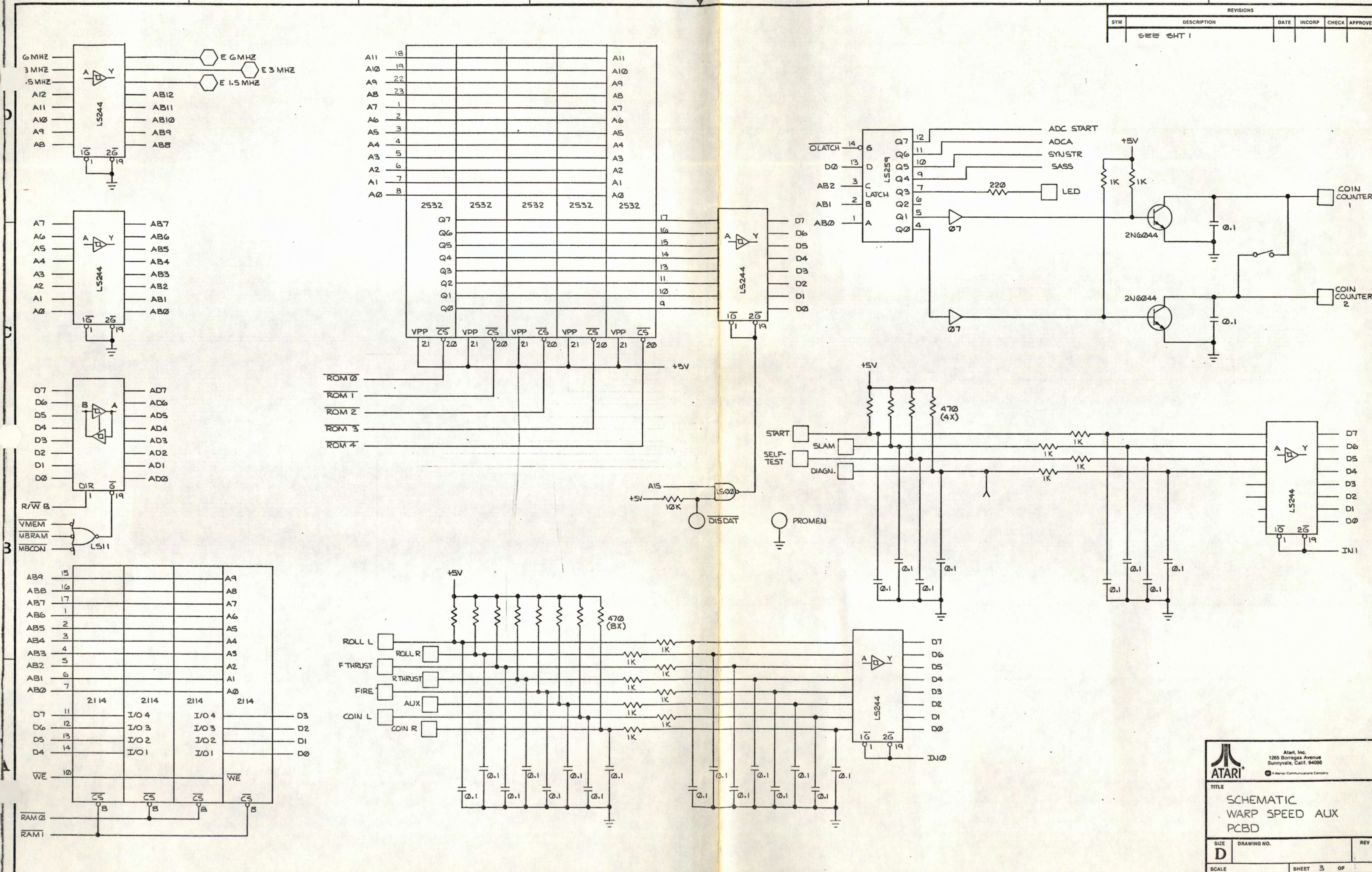
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AD4
AD3
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AD1
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DIR
R/W B
VMEM
MBRAM
MBCON
LS11
2532
VPP
CS
ROM Ø
ROM 1
ROM 2
ROM 3
ROM 4
+5V
A15
10K
LS00
DISDAT
PROMEN
OLATCH
LS259
LATCH
ADC START
ADCA
SYNSTR
SASS
220
LED
1K
2N6044
Ø7
Ø.1
COIN COUNTER 1
COIN COUNTER 2
470 (4X)
START
SLAM
SELF-TEST
DIAGN.
IN1
2114
I/O 4
I/O 3
I/O 2
I/O 1
WE
RAM Ø
RAM 1
470 (8X)
ROLL L
ROLL R
F THRUST
R THRUST
FIRE
AUX
COIN L
COIN R
INØ
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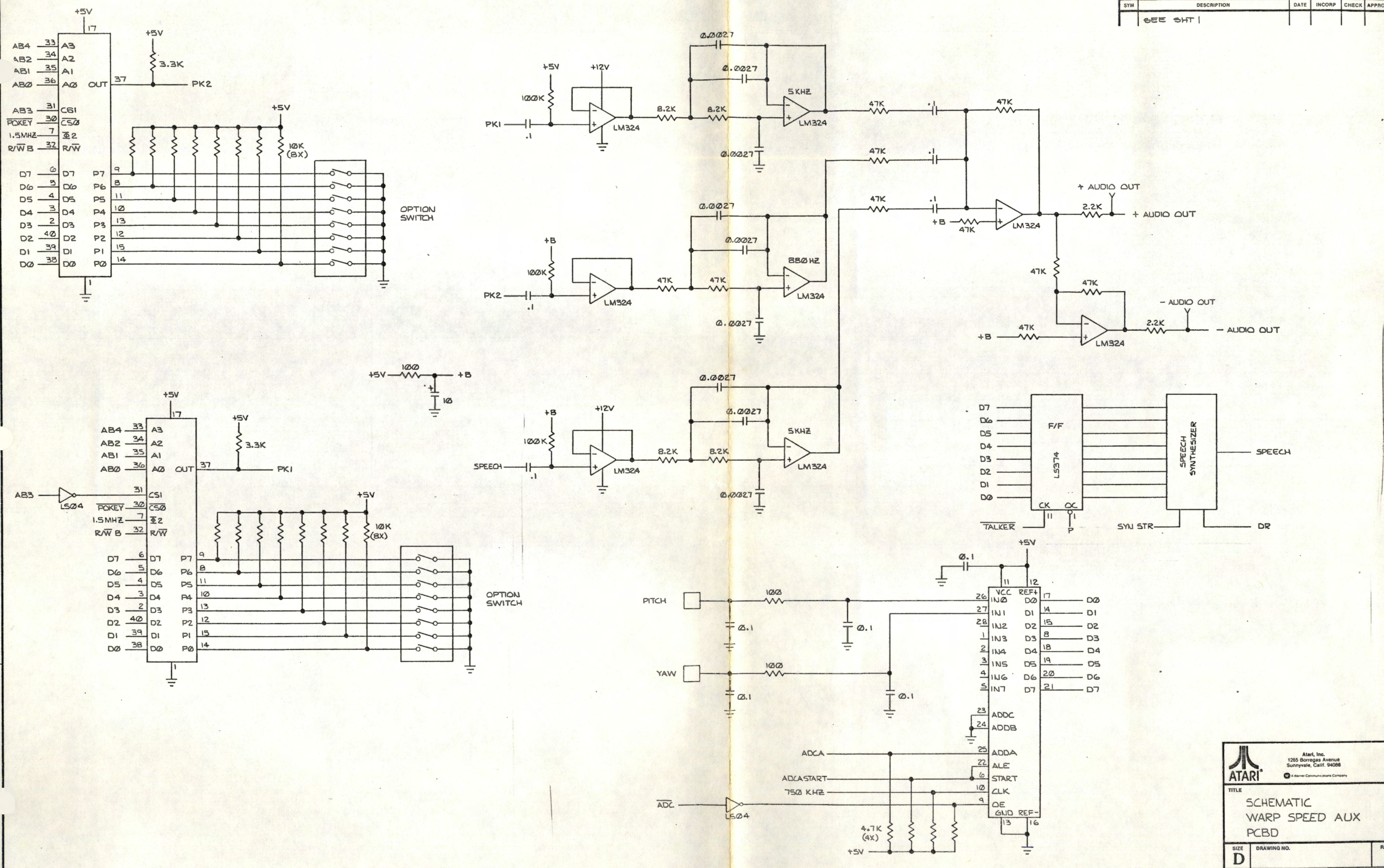

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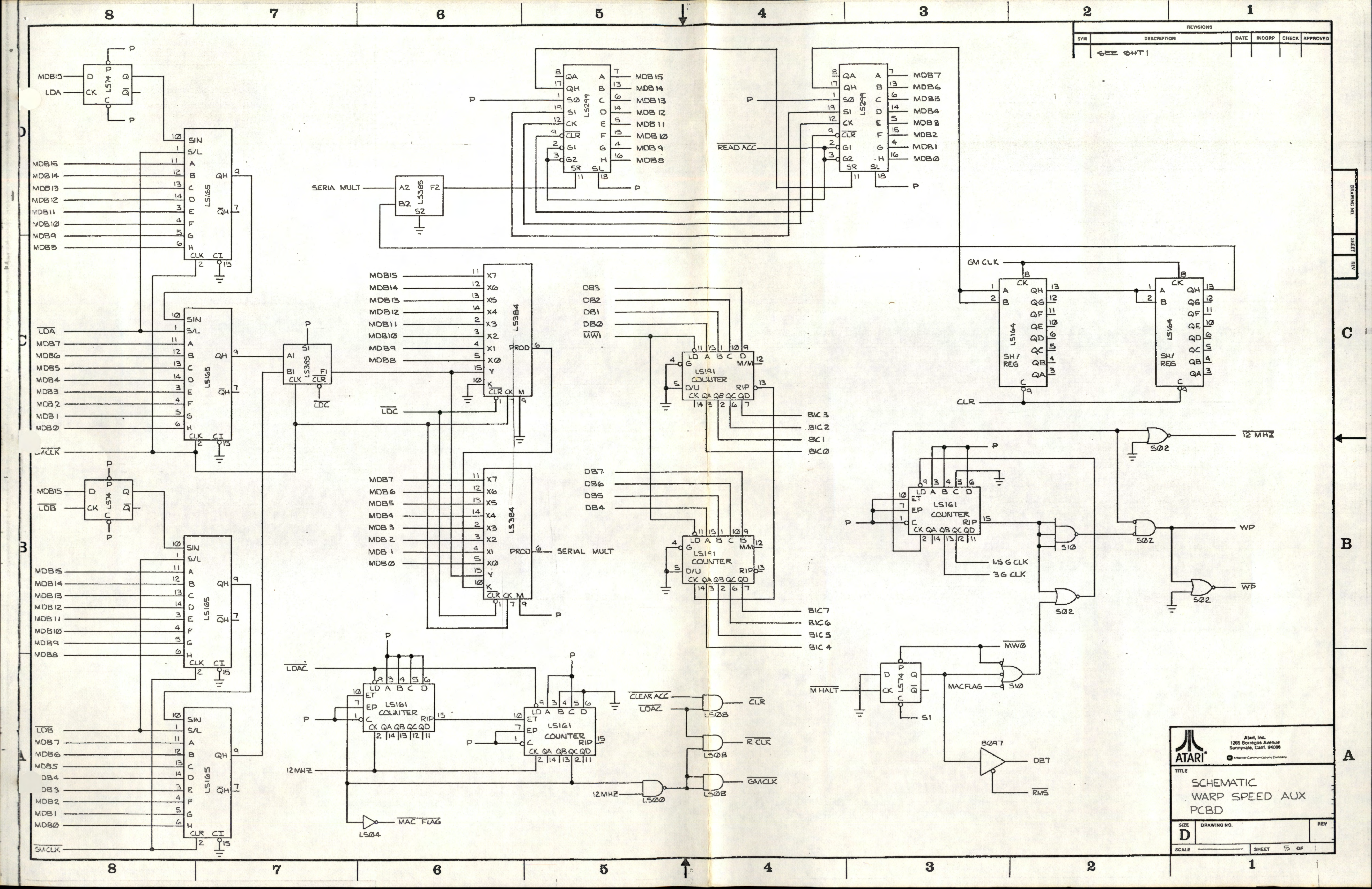
SCALE SHEET 4 OF



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LS10
S02
S10
8097
SERIA MULT
SERIAL MULT
READ ACC
GM CLK
CLR
LDA
LDB
LDC
LDAC
SMCLK
CLEAR ACC
R CLK
GMCLK
12MHZ
12 MHZ
MAC FLAG
MACFLAG
M HALT
MWØ
MW1
WP
1.5 G CLK
3G CLK
DB7
RMS
BIC 3
BIC 2
BIC 1
BICØ
BIC7
BIC6
BIC5
BIC 4
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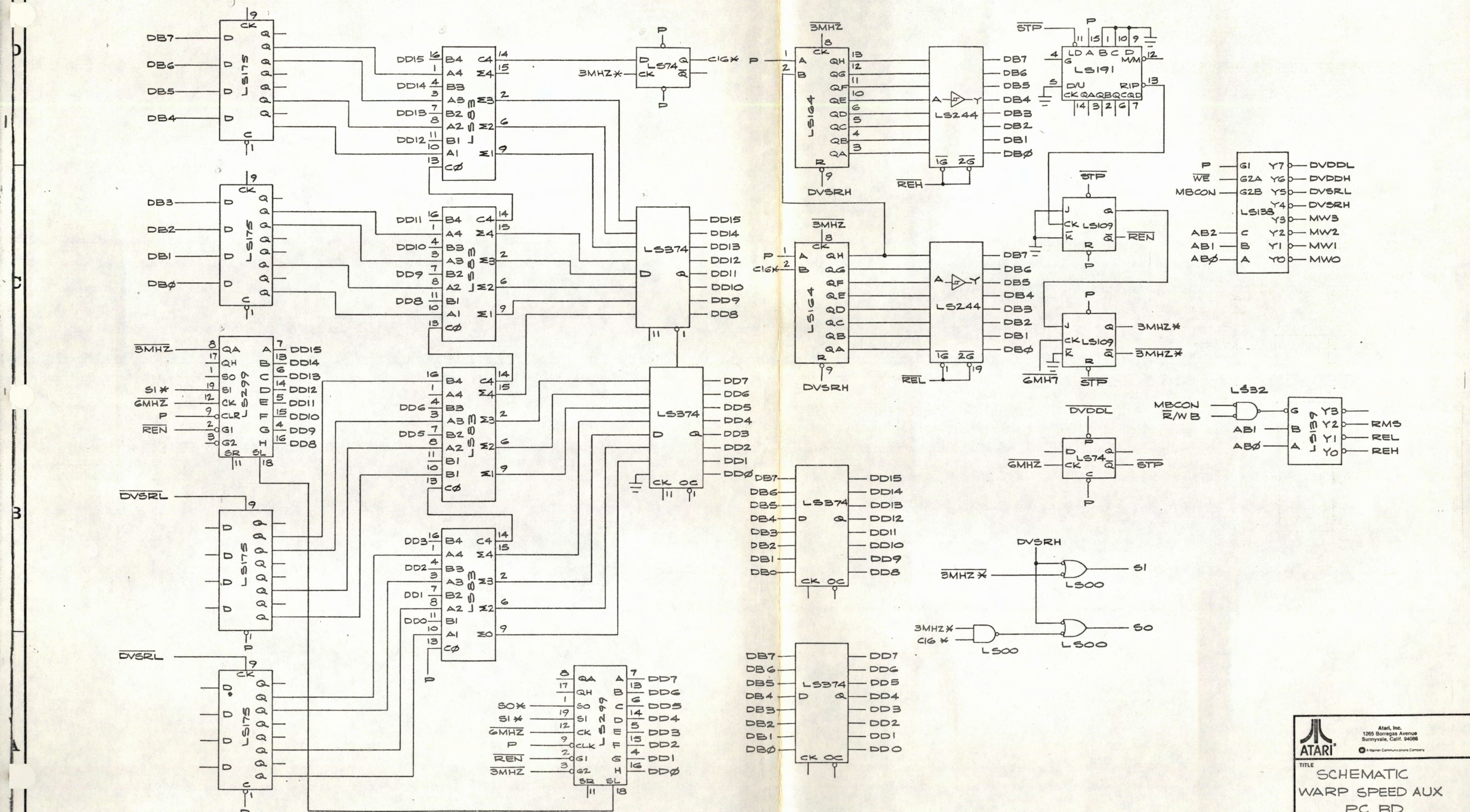

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SCALE | SHEET 6 OF

SYM	DESCRIPTION	DATE	INCORP	CHECK	APPROVED
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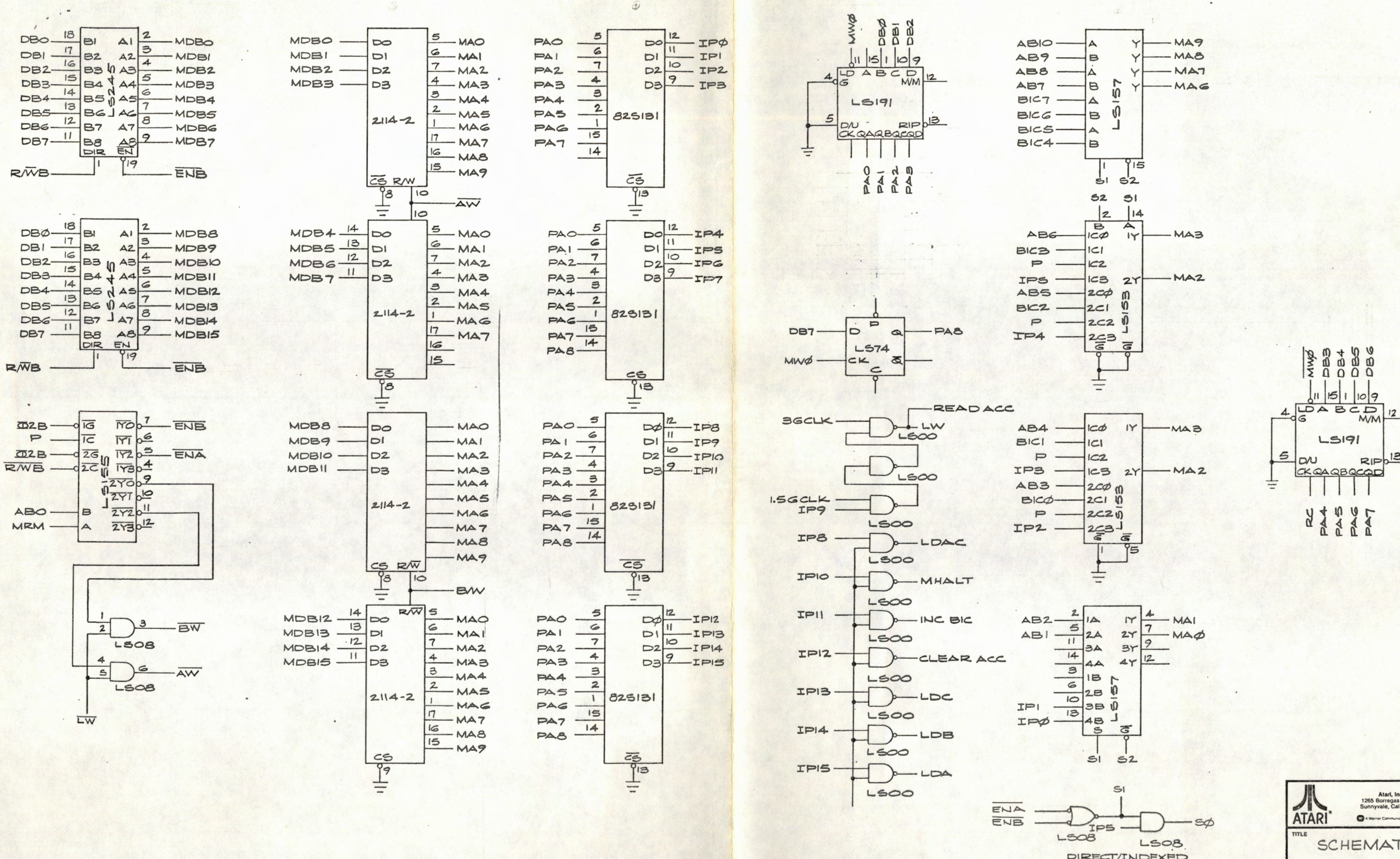

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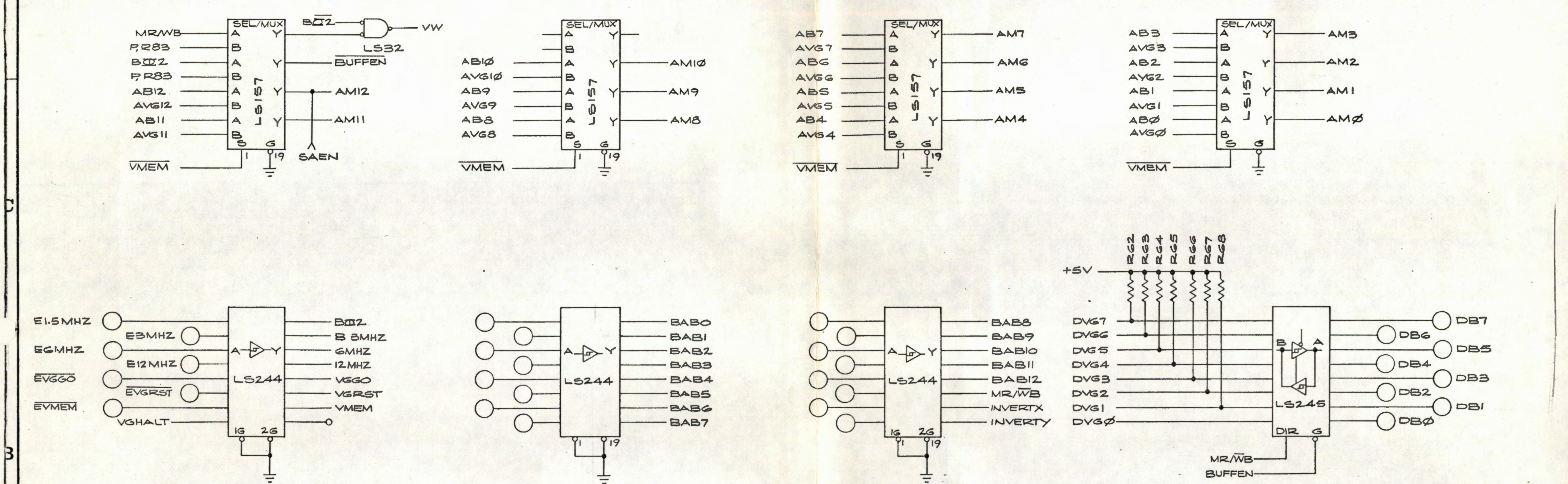
TITLE

SCHEMATIC
WARP SPEED AUX
PC BD

SIZE D | DRAWING NO. | REV

SCALE | SHEET 7 OF 7



12/22

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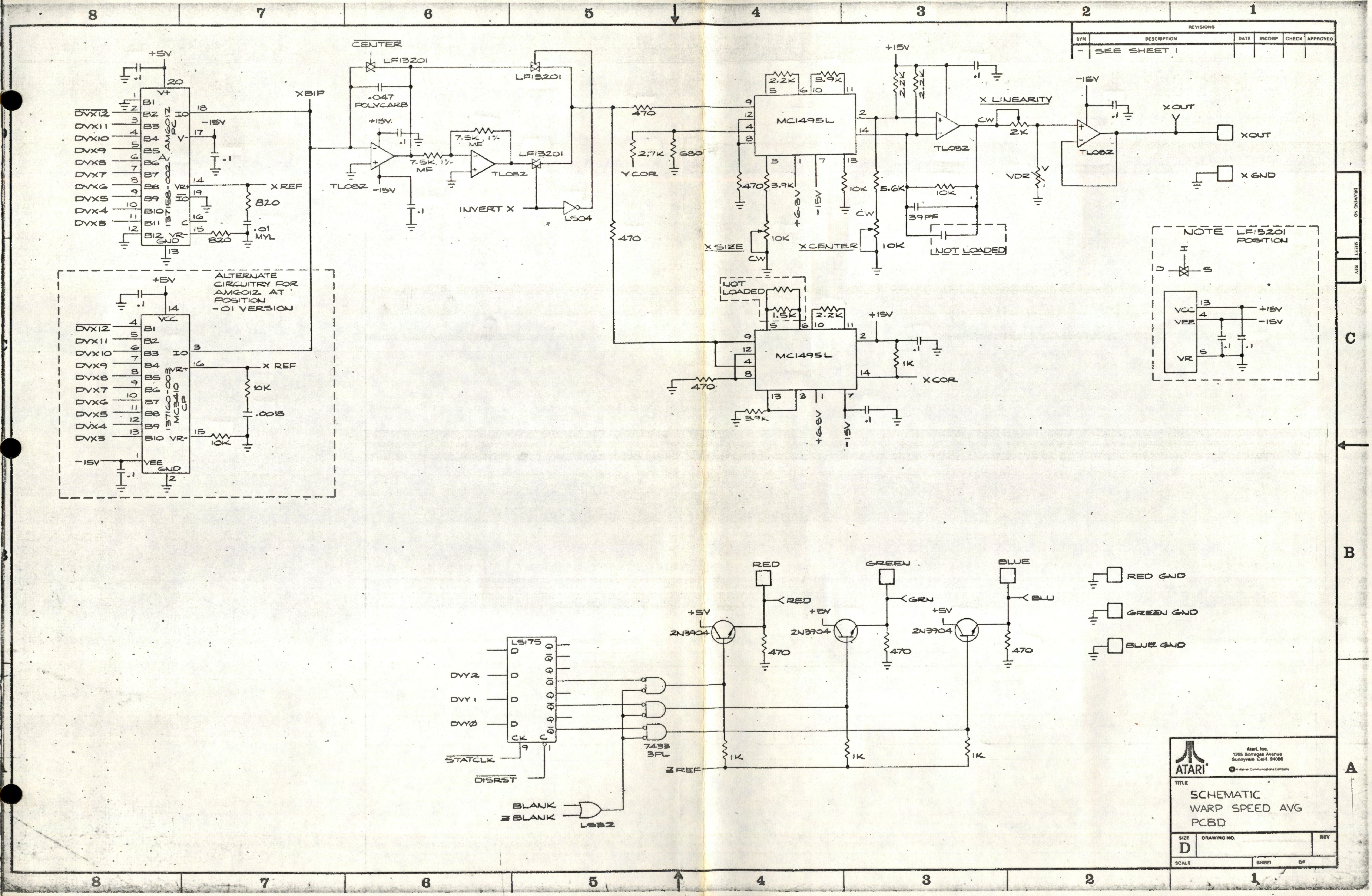
TITLE
SCHEMATIC
WARP SPEED AUX
PC BD

SIZE D | DRAWING NO. | REV
SCALE | SHEET | OF


REVISIONS
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+5V
DVX12
DVX11
DVX10
DVX9
DVX8
DVX7
DVX6
DVX5
DVX4
DVX3
137158-002, AMG012 PC
XBIP
-15V
X REF
820
.01 MYL
ALTERNATE CIRCUITRY FOR AMG012 AT POSITION -01 VERSION
137160-003 MC3410 CP
10K
.0018
CENTER
LF13201
.047 POLYCARB
+15V
TL082
7.5K 1% MF
INVERT X
LS04
470
2.2K
3.9K
MC1495L
2.7K
680
YCOR
+6.8V
10K
X SIZE
CW
X CENTER
5.6K
39PF
NOT LOADED
X LINEARITY
2K
VDR
XOUT
X OUT
X GND
NOTE LF13201 POSITION
VCC
VEE
VR
1.5K
1K
XCOR
RED
GREEN
BLUE
GRN
BLU
2N3904
RED GND
GREEN GND
BLUE GND
LS175
DVY2
DVY1
DVYØ
STATCLK
DISRST
7433 3PL
Z REF
BLANK
Z BLANK
LS32
ATARI
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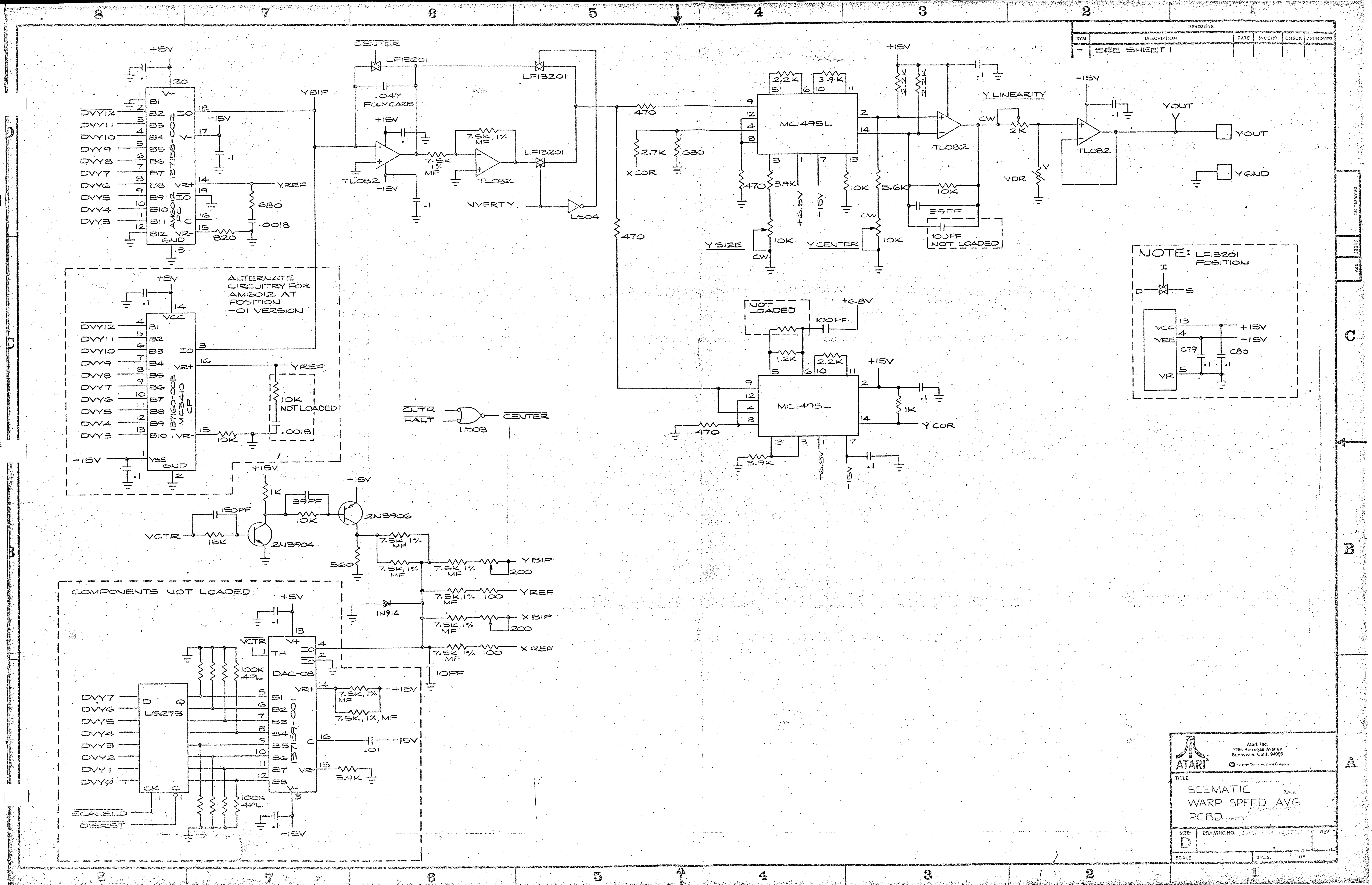
TITLE
SCHEMATIC
WARP SPEED AVG
PCBD
SIZE D
DRAWING NO.
REV
SCALE
SHEET
OF



REVISIONS
SYM
DESCRIPTION
DATE
INCORP
CHECK
APPROVED
SEE SHEET 1
+5V
AMG012 PC
137158-002
YBIP
CENTER
LF13201
.047 POLYCARB
TL082
7.5K 1% MF
INVERTY
LS04
YREF
680
.0018
820
ALTERNATE CIRCUITRY FOR AMG012 AT POSITION -01 VERSION
137160-003 MC3410 CP
10K NOT LOADED
CNTR
HALT
LS08
CENTER
MC1495L
XCOR
2.7K
470
3.9K
Y SIZE
Y CENTER
5.6K
100PF NOT LOADED
39PF
Y LINEARITY
2K
VDR
YOUT
YGND
NOT LOADED
100PF
+6.8V
1.2K
2.2K
+15V
-15V
1K
Y COR
NOTE: LF13201 POSITION
VCC
VEE
VR
C79
C80
VCTR
15K
150PF
2N3904
2N3906
39PF
10K
560
YBIP
200
YREF
100
XBIP
XREF
1N914
10PF
COMPONENTS NOT LOADED
DAC-08
137159-001
LS273
100K 4PL
DVY7
DVY6
DVY5
DVY4
DVY3
DVY2
DVY1
DVYØ
SCALSLD
DISRST
7.5K, 1%, MF
.01
3.9K
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TITLE
SCEMATIC
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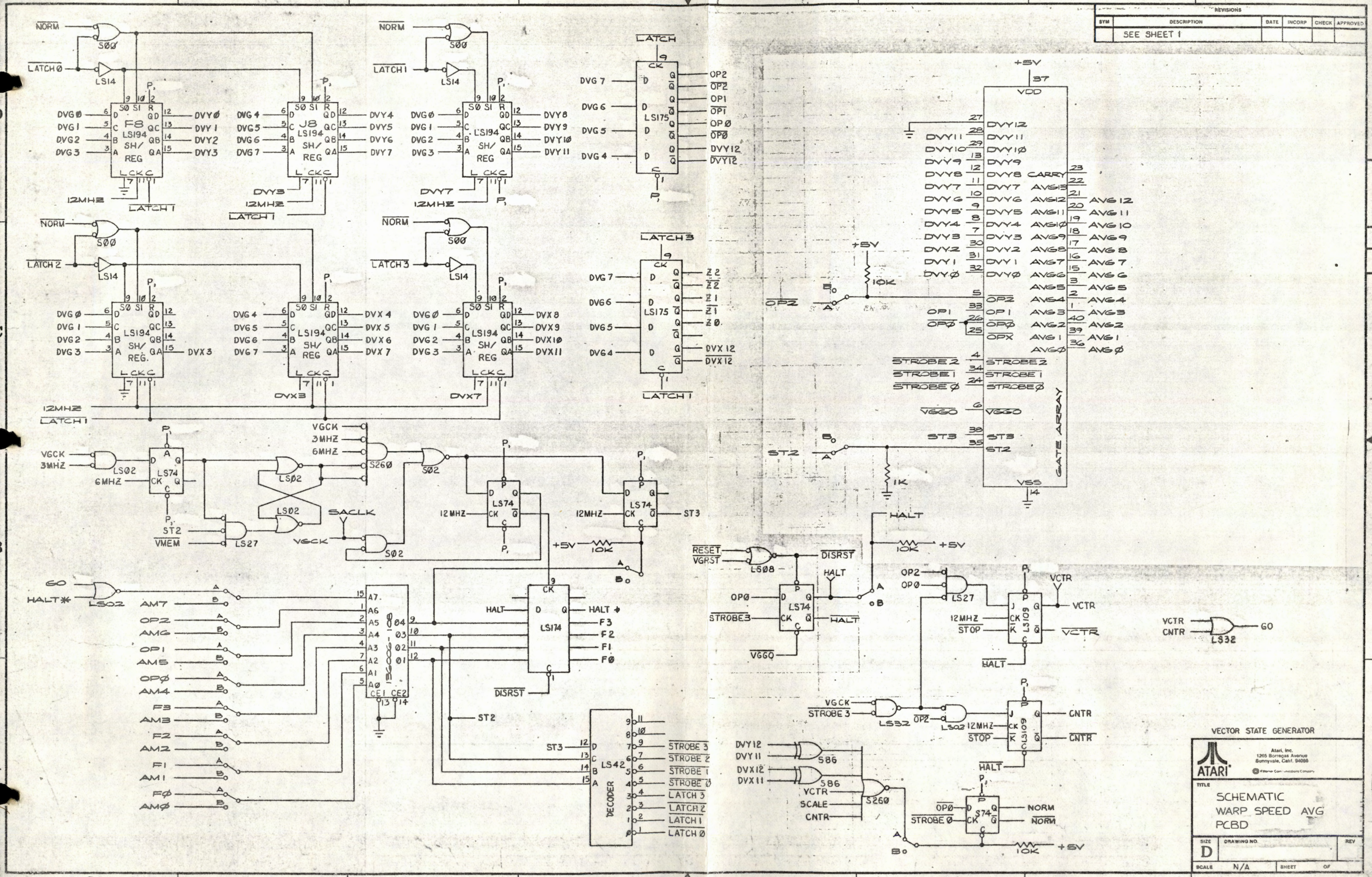
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DESCRIPTION
DATE
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CHECK
APPROVED
SEE SHEET 1
GATE ARRAY
VECTOR STATE GENERATOR
ATARI
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TITLE
SCHEMATIC
WARP SPEED AVG
PCBD
SIZE
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REV
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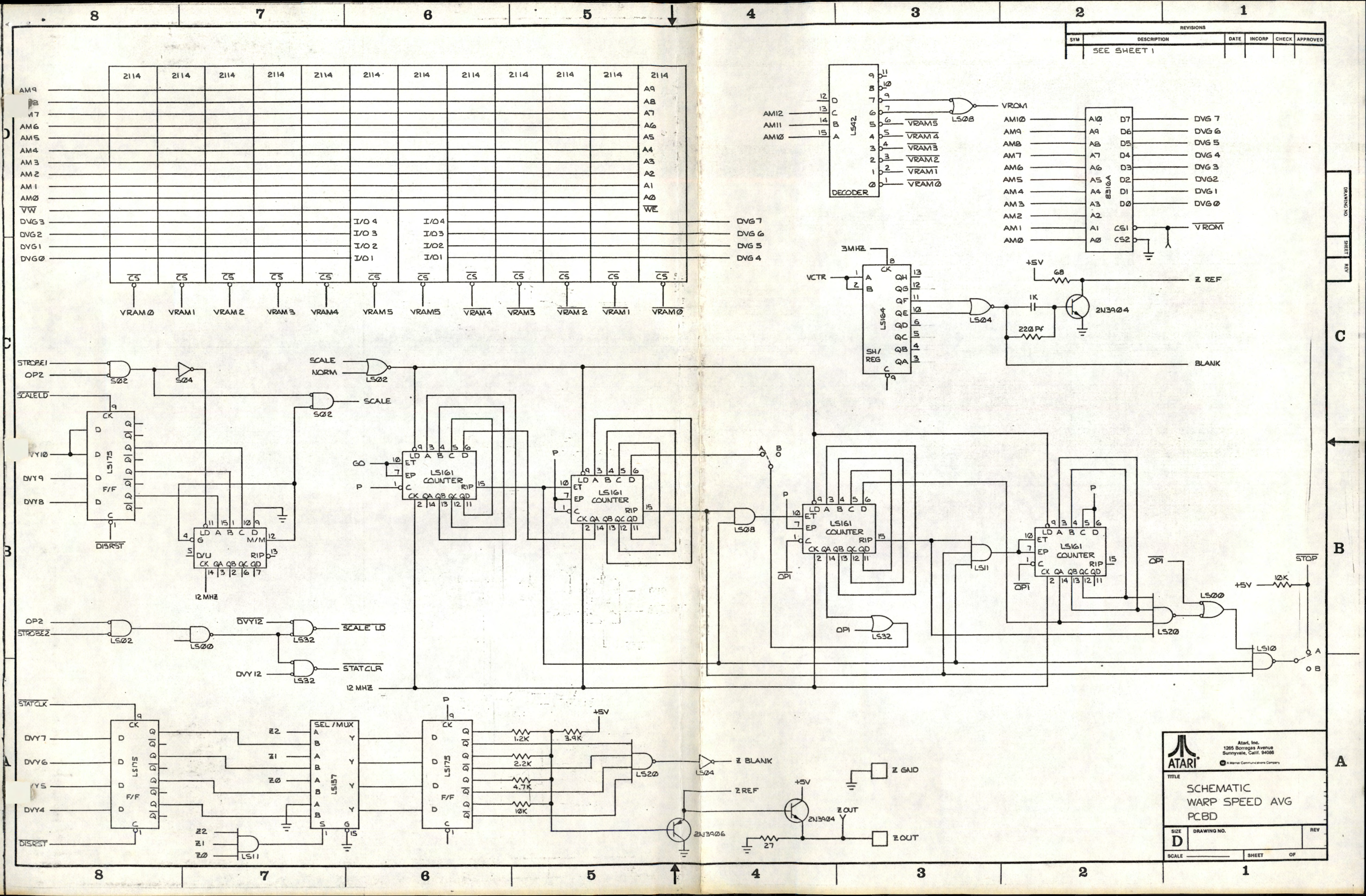
OF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DESCRIPTION
DATE
INCORP
CHECK
APPROVED
SEE SHEET 1
2114
AM9
AM8
AM7
AM6
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AM4
AM3
AM2
AM1
AMØ
VW
DVG3
DVG2
DVG1
DVGØ
A9
A8
A7
A6
A5
A4
A3
A2
A1
AØ
WE
I/O 4
I/O 3
I/O 2
I/O 1
DVG7
DVG6
DVG5
DVG4
CS
VRAMØ
VRAM1
VRAM2
VRAM3
VRAM4
VRAM5
LS42
DECODER
AM12
AM11
AMIØ
LS08
VROM
8316A
A1Ø
D7
D6
D5
D4
D3
D2
D1
DØ
CS1
CS2
3MHZ
VCTR
LS164
SH/REG
QH
QG
QF
QE
QD
QC
QB
QA
LS04
+5V
68
1K
22Ø PF
2N3904
Z REF
BLANK
STROBE1
OP2
SØ2
SØ4
SCALE LD
SCALE
NORM
LS02
DVY1Ø
DVY9
DVY8
LS175
F/F
DISRST
LD A B C D
M/M
D/U
RIP
12 MHZ
GO
P
ET
EP
LS161
COUNTER
CK QA QB QC QD
LS08
LS11
LS32
OP1
LS20
LS00
LS10
STOP
10K
DVY12
STATCLR
STROBE2
LS00
DVY 12
STATCLK
DVY7
DVY6
DVY5
DVY4
SEL/MUX
LS157
Z2
Z1
ZØ
1.2K
3.9K
2.2K
4.7K
10K
Z BLANK
Z GND
2N3906
Z OUT
27
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